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TO 16-35TS537-5

CRYSTAL IMPEDANCE METER TS-537/TSM

DEPARTMENTS OF THE ARMY AND THE AIR FORCE
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CRYSTAL IMPEDANCE METER TS-537/TSM

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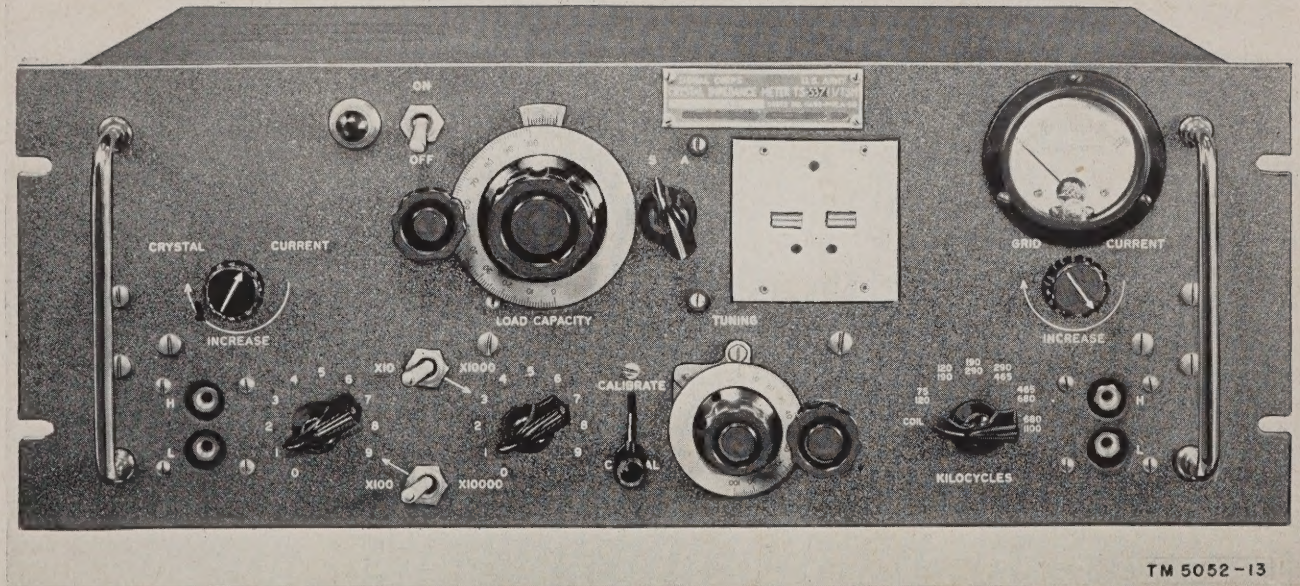


Figure 1. Crystal Impedance Meter TS–537/TSM.

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

This manual is published for the information and guidance of personnel to whom this equipment is issued. It contains information on the operation, organizational maintenance, and field maintenance of Crystal Impedance Meter TS–537/TSM (fig. 1). This manual applies only to Crystal Impedance Meter TS–537/TSM.

2. Appendixes

This manual contains two appendixes. Appendix I contains references to other sources of information applicable to the equipment; appendix II contains an identification table of parts.

3. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army matérièl and equipment, and for guidance in performing preventive maintenance.

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745–45–5 (Army), NAV DEPT SERIAL 85POO (Navy), and AFR 71–4 (Air Force).

b. DA AGO Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in SR 700–45–5.

c. AF Form 54, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Matériel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700–45–5 and AFR 65–26.

d. DA AGO Form 419, Preventive Maintenance Checklist for Signal Corps Equipment, will be prepared in accordance with instructions on the back of the form.

e. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

4. Purpose and Use

Crystal Impedance Meter TS–537/TSM (fig. 1) is designed specifically to test quartz crystal units (crystal oscillator plates in holders) in the frequency range of 75 to 1,100 kc (kilocycles) for conformance with Military Specifications MIL–C–3098 and MIL–C–10405 (Sig C) and specified crystal data sheets. Testing is accomplished by measuring directly the effective series-resonant and anti-resonant resistances of piezoelectric quartz crystal units. (Certain crystal units are operated at series resonance while others are operated at antiresonance.) With the crystal impedance (CI) meter connected to suitable frequency measuring equipment (fig. 6), the equivalent electrical parameters (fig. 5) of the crystal units also can be measured. The series capacitance, C, can be computed (par. 14*b*) from the following: the static capacitance, C_o, of the crystal unit (which can be measured by any conventional l-f (low-frequency) capacity measuring unit), the load capacitance, C_1, of the circuit (the value of which is selected by the setting of LOAD CAPACITY dial (I-2), and which can be transposed into $\mu\mu$f (micromicrofarad) by means of the calibration chart (par. 13), and the series, and antiresonant frequencies. The inductance, L, can be computed from C and the nominal frequency of the crystal unit. From these electrical parameters the PI (performance index) of the crystal unit under test can be calculated (par. 14*b*(6)); the PI is a measure of the activity of the crystal under test. The greater the activity of a crystal unit, the more satisfactory it is for communication purposes.

5. Description

a. General. Crystal Impedance Meter TS–537/TSM is one of the principal components of Crystal Test Set AN/TSM–3 (fig. 2). The other components of the test set are two Cases CY–23/TSM and Crystal Impedance Meter TS–330/TSM. Refer to TM 11–5051 for complete information on Crystal Impedance Meter TS–330/TSM.

b. Crystal Impedance Meter TS–537/TSM. The crystal impedance meter (fig. 1) is inclosed in a black, wrinkle-finished metal case designed for rack mounting. The over-all dimensions of the unit are 19 inches long by 10½ inches wide by 7 inches high. The panel contains a meter, a crystal socket assembly, receptacles, and various controls (par. 11). The meter operates from a power source of 115-volt ac (alternating current), 50 to 1,720 cps (cycles per second). Furnished with the meter are a 4-foot, r-f (radio-frequency) pick-up cable assembly with plug attached and a load capacitance calibration

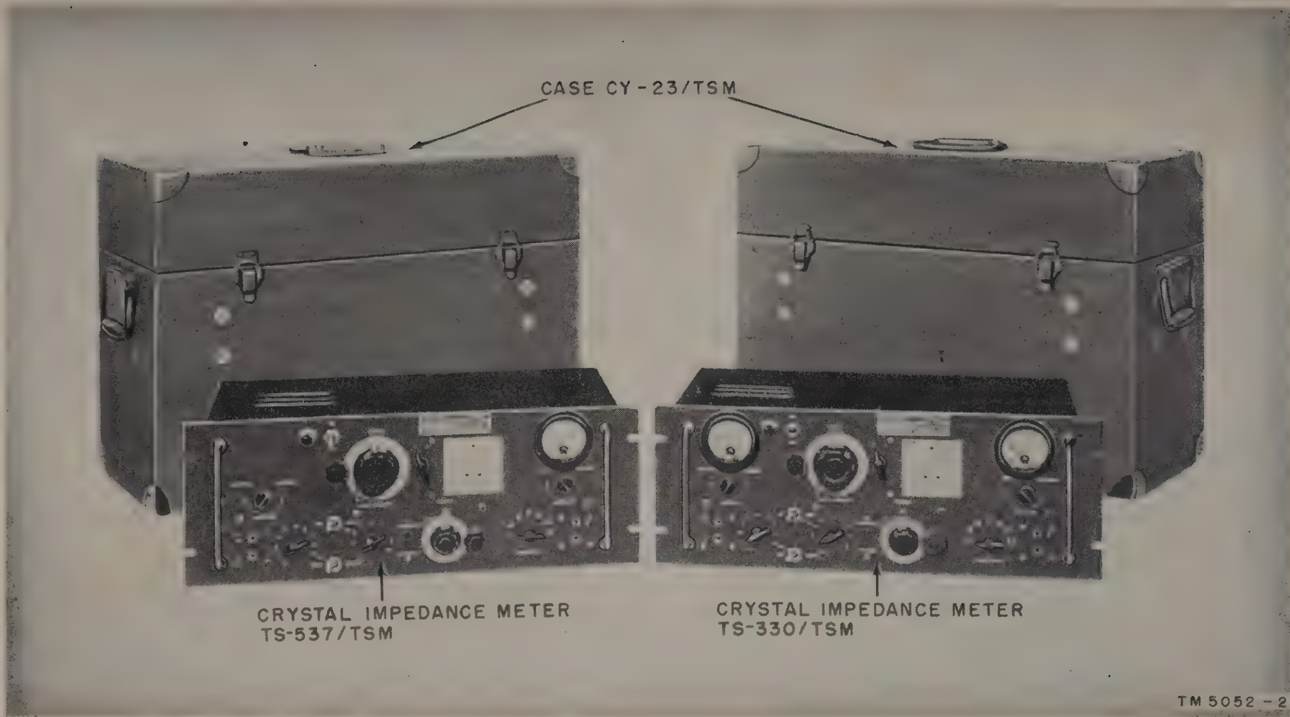


Figure 2. Crystal Test Set AN/TSM-3, components.

chart (par. 13). The meter is portable; for carrying purposes, it is placed inside Case CY–23/TSM (which is not part of Crystal Impedance Meter TS–537/TSM, but part of the over-all Crystal Test Set AN/TSM–3).

6. Technical Characteristics

The characteristics of the Crystal Impedance Meter TS–537/TSM are as follows:

Frequency ranges............Six ranges: 75 to 120 kc, 120 to 190 kc, 190 to 290 kc, 290 to 465 kc, 465 to 680 kc, 680 to 1,100 kc; first position of range switch selects sockets to which a plate and grid coil can be connected for extending the range downward. Ranges overlap.

Resistance calibration ranges..By using a toggle switch and two selector switches, the following resistance ranges are obtainable:
0 to 990 ohms in 10-ohm steps, 0 to 9,900 ohms in 100-ohm steps, 0 to 99,000 ohms in 1,000-ohm steps.

Load capacitance calibration..12 to 110 $\mu\mu$f. Dial marked 0 to 100. A calibration chart is supplied with each unit to translate dial markings to load capacity in $\mu\mu$f.

Required power supply.......115-volt ac, 50 to 1,720 cps.

7. Packaging Data

a. Crystal Impedance Meter TS–537/TSM. This meter is packed for shipment in a wooden box complying with requirements of Joint Army-Navy specifications as described in JAN–P–100 and JAN–P–116.

(1) The packaged equipment is 20 inches high by 17 inches wide by 29 inches deep; it has a volume of 5.7 cubic feet and weighs 60 pounds.

(2) The following list indicates the contents of the packing case:

Contents	Notes
1 Crystal Impedance Meter TS-537/TSM.	Tubes not inserted in sockets.
3 tubes, electron: type 6V6GT.	Packed inside meter.
3 tubes, electron: type 5Y3GT.	Packed inside meter.
6 tubes, electron: type 0C3W.	Packed inside meter.
3 Fuse FU-26: 1 ampere, 250 volts, glass inclosed.	One in equipment, two running spares.
3 lamps incandescent: Sig C Lamp LM-27.	One in equipment, two running spares.
1 cable assembly, r-F: pick-up.	Packed in cover of Case CY-23/TSM.
1 chart, calibration of load capacitance.	Packed in cover of Case CY-23/TSM.
2 technical manuals for Crystal Impedance Meter TS-537/TSM.	Packed in cover of Case CY-23/TSM.

b. Crystal Test Set AN/TSM-3. This equipment is shipped in two Cases CY-23/TSM. Both cases are surrounded with excelsior and packed in a wooden shipping box. The packaged equipment is 35 inches high by 29 inches wide by 39 inches deep; it has a volume of 23.0 cubic feet and weighs 206 pounds.

CHAPTER 2

OPERATING INSTRUCTIONS

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

8. Service upon Receipt of New Equipment

a. GENERAL. Crystal Impedance Meter (CI) TS-537/TSM is shipped in export packing cases. When uncrating and unpacking, be careful not to damage the equipment by thrusting tools into the interior. Do not damage the packing material more than necessary. Store the inside packaging in the shipping container for future use.

b. STEP-BY-STEP INSTRUCTIONS FOR UNCRATING AND UNPACKING.

(1) Remove the nails with a nail puller and lift off the top of the shipping container.

(2) Cut the tape and seals of the case liner so that the waterproof paper is damaged as little as possible.

(3) Lift out the fiberboard pads used for blocking and bracing the equipment.

(4) Lift out the packaged CI meter. Carefully remove the waterproof wrap.

(5) Cut the tape that seals the top flaps of the carton; be careful not to damage the carton. Open the carton and remove the moisture-vaporproofed package.

(6) Cut open the moisture-vaporproofed barrier. Remove the inner carton.

(7) Open the inner box and remove the top cushioning cells and/or pads. Remove the desiccant and packaged technical manuals. Lift out the CI meter.

(8) Store the interior packaging material (except the desiccant) in the inner carton for future use. Remove the material protecting the front panel of the set.

(9) Thoroughly inspect the equipment for possible damage during shipment.

(10) Check the contents of the packing case against the master packing slip.

9. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 8 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications pertaining to changes in the wiring of the equipment. If any changes in wiring have been made, note the changes in this technical manual, preferably on the schematic diagram.

c. Check the operating controls for ease of rotation.

d. Check the equipment for calibration accuracy (ch. 5, sec. IV). Adjust as required.

e. Prepare the equipment for use in accordance with the instructions in paragraph 10.

10. Preparation for Use

Place the equipment on a bench or in a standard relay rack and proceed as follows:

a. Check the front panel for chips, cracks, and damaged parts.

b. Check controls and dials for ease of movement and positive action.

c. Remove all dust, dirt, and grease accumulations by wiping with a clean, dry cloth.

d. Place the tubes into their appropriate sockets.

e. Refer to section II, this chapter, for information concerning the operating procedures. Read these instructions carefully before using the equipment.

Section II. OPERATION

11. Panel Controls and Connections

The following table lists the controls and receptacles on the front panel of Crystal Impedance Meter TS–537/TSM (fig. 3) and gives their locations and functions; the r-f output is discussed also.

Control	Location	Function
ON-OFF switch (S8).	Above and to left of LOAD CAPACITY dial.	A-C power switch.
CALIBRATE—CRYSTAL switch (S7).	Below LOAD CAPACITY dial.	The CRYSTAL position is used to switch the crystal into the oscillator circuit. Move the switch to the CALIBRATE position after the circuit is initially adjusted to the test crystal to substitute the equivalent resistance for the unit being tested.
Kilocycles switch (S5).	Below and to left of GRID CURRENT meter.	The oscillator may be tuned to any frequency between 75 kc. and 1,100 kc. by means of this range selector switch and the oscillator TUNING control. In the COIL position, plug-in coils can be used to extend the range downward.

Control	Location	Function
TUNING control (C1).	Below the crystal socket.	The TUNING control is used in connection with the kilocycles switch (S5) for tuning the oscillator to the desired frequency.
Crystal socket.	To right of LOAD CAPACITY dial.	A two-pin crystal socket with a center-to-center pin spacing of .5 inch to 1.25 inches; Crystal Holder FT-249 may be plugged in for test.
S—A switch (S6).	To right of LOAD CAPACITY dial.	Switch (marked S—A) is used to select either series-resonant or anti-resonant operation of the crystal unit under test. In the S position, the crystal unit operates at series resonance; in the A position, the crystal unit operates at antiresonance.
LOAD CAPACITY CONTROL (C2).	Top center of panel.	This control is used for setting the load capacitance C_1 in anti-resonant operation. Its dial is calibrated and has a vernier drive and an indicator. A calibration chart is provided with the equipment for translation of the dial readings into capacitance (in $\mu\mu f$).
Decade resistor switches (S1, S2) and range toggle switches (S3, S4).	Below and to left of LOAD CAPACITY dial.	These controls consist of two selector switches and two toggle switches. They are used to select a resistant equivalent to the crystal resistance.
CRYSTAL CURRENT control (R42).	Left side of panel.	By means of this control, the amount of current passing through the crystal unit under test can be varied.
GRID CURRENT meter (M1).	Right side of panel.	The GRID CURRENT meter is a d-c microammeter used to indicate a convenient proportion of the total rectified grid current.
GRID CURRENT control (R41).	Right side of panel.	This control is used to vary the setting of a shunt resistor across the GRID CURRENT meter so that convenient readings may be obtained.
Vacuum-tube voltmeter receptacles H and L (J1, J2, J3, J4).	Lower right and left sides of panel.	These jacks provide connections to voltmeters for measurement of voltage across the crystal unit.
Light indicator (I–1).	Left of ON-OFF switch S8.	Incandescent lamp lights when current is flowing through primary of transformer T1.
Coaxial connector receptacle (J5).	Rear of chassis.	This coaxial connector receptacle provides means by which a small portion of the r-f output of the oscillator may be connected (via r-f cable assembly W1) to frequency measuring equipment (ch. 4).

12. Operation Under Usual Conditions

a. MEASUREMENT OF SERIES-RESONANT RESISTANCE. Prior to measurement, refer to the pertinent crystal data sheet, if available.

Caution: To prevent damage to the meter, adjust the CRYSTAL CURRENT and GRID CURRENT controls to their minimum positions (maximum counterclockwise position) before turning on the instrument.

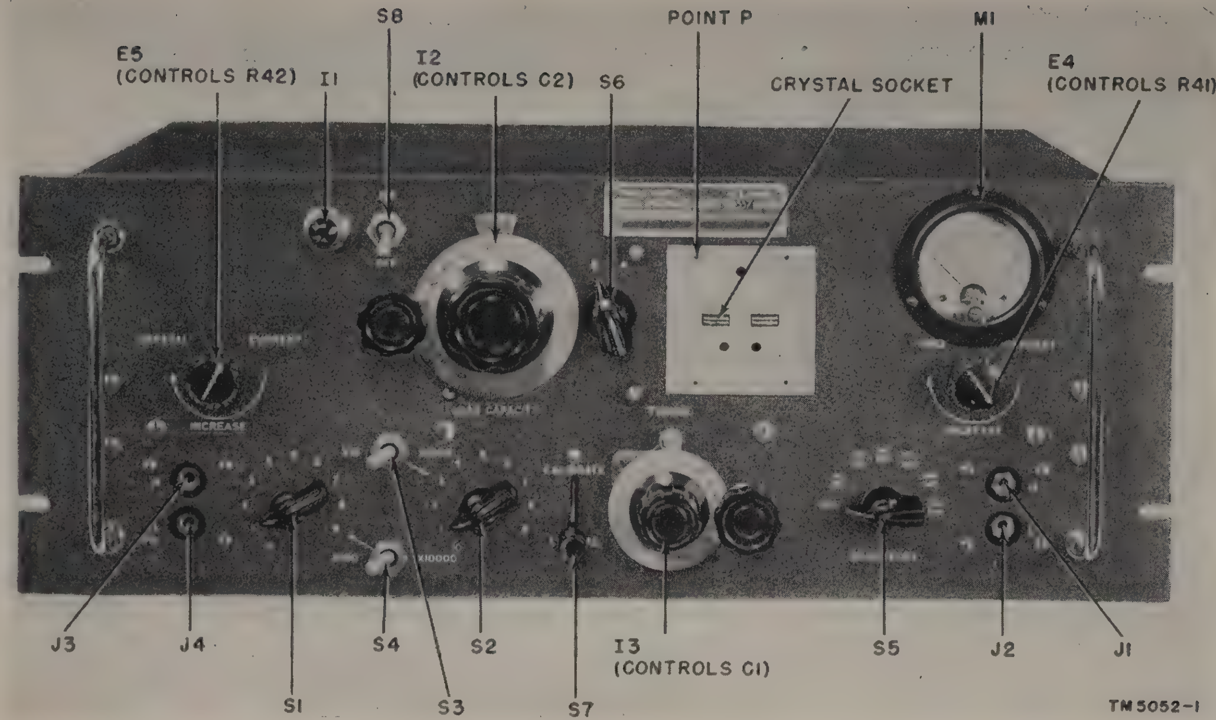


Figure 3. Crystal Impedance Meter TS-537/TSM, panel view.

(1) Insert the a-c cable assembly (W2) plug PI in a 115-volt, 50- to 1,720-cps, a-c source.

(2) Throw the ON-OFF switch to ON. Allow 15 minutes for the equipment to warm up.

(3) Move the CALIBRATE—CRYSTAL switch to the CRYSTAL position.

(4) Set the KILOCYCLES switch to the proper frequency range.

(5) Turn the S—A switch to position S.

(6) Insert the crystal unit in the crystal socket.

(7) Increase the GRID CURRENT control slightly in a clockwise direction.

(8) Adjust the TUNING control for a maximum grid current reading. It may be necessary to increase the GRID CURRENT and CRYSTAL CURRENT controls in order to obtain a convenient GRID CURRENT meter reading. The crystal current should be maintained as low as possible with the sensitivity of the GRID CURRENT meter at maximum. (The crystal current can be computed from the formula in paragraph 14*b*(5)(*a*).)

Caution: Do not increase the CRYSTAL CURRENT control more than is necessary, because damage to crystal and equipment may result.

(9) Make an approximate measurement of the crystal frequency by connecting cable assembly W1 from J5 to a radio receiver with the bfo (beat-frequency oscillator) turned on (refer to ch. 4).

(10) Set the decade resistors to the maximum resistance specified in the pertinent crystal data sheet for the particular crystal under test.

(11) Move the CALIBRATE—CRYSTAL switch to the CALIBRATE position. If the GRID CURRENT meter needle goes off scale, immediately switch enough resistance (by means of the decade resistors) into the circuit to bring the GRID CURRENT meter reading back to the value obtained in the CRYSTAL position.

(12) Adjust the TUNING control so that the signal is at zero beat with the frequency measured in (9) above.

(13) Move the CALIBRATE—CRYSTAL switch to the CRYSTAL position.

(14) Adjust the GRID CURRENT control to obtain any convenient value of meter reading. This adjustment must remain fixed throughout the remainder of the test.

(15) Switch to the CALIBRATE position.

(16) Adjust the decade resistors to obtain the same value of GRID CURRENT meter reading that prevailed when the CALIBRATE—CRYSTAL switch was in the CRYSTAL position.

(17) Readjust the TUNING control to obtain the same frequency that prevailed in the CRYSTAL position ((9) above).

(18) Repeat the steps outlined in (16) and (17) above, if necessary, to obtain identical grid current and frequency values in both the CALIBRATE and CRYSTAL positions.

(19) Read the value of resistance from the settings of the decade resistors. This is the effective series-resonant resistance of the crystal unit.

(20) Move the CALIBRATE—CRYSTAL switch to the CRYSTAL position. Make an accurate measurement of the operating frequency by connecting cable assembly W1 to an appropriate frequency measuring instrument such as the following: Frequency Meter FR-4, Frequency Measuring Assembly CY–93/FSM–1, or Frequency Meter Set SCR–211. Selection of the meter used depends on the intended use and the accuracy desired (ch. 4).

b. Measurement of Antiresonant Resistance. Refer to the pertinent crystal data sheet, if available, prior to measurement.

Caution: To prevent damage to the meter, adjust the CRYSTAL CURRENT and GRID CURRENT controls to their minimum positions (maximum counterclockwise position) before turning the instrument on.

(1) Insert the a-c cable assembly (W2) plug PI in a 115-volt, 50- to 1,720-cps, a-c source.

(2) Throw the ON-OFF switch to ON. Allow 15 minutes for the equipment to warm up.

(3) Turn the CALIBRATE—CRYSTAL switch to the CRYSTAL position.

(4) Set the KILOCYCLES switch to the frequency range of the crystal.

(5) Turn the S—A switch to position S.

(6) Adjust the LOAD CAPACITY dial to the proper setting. Calibration data are given in the calibration chart (par. 13) supplied with the instrument.

(7) Insert the crystal unit in the crystal socket.

(8) Increase |the GRID CURRENT control slightly in a clockwise direction.

(9) Adjust the TUNING control for maximum GRID CURRENT meter reading. It may be necessary to increase the GRID CURRENT and CRYSTAL CURRENT controls in order to obtain a convenient GRID CURRENT meter reading. The crystal current should be maintained as low as possible with the GRID CURRENT control knob at maximum clockwise position.

Caution: Do not increase the CRYSTAL CURRENT control more than is necessary, because damage to crystal and equipment may result.

(10) Turn switch S—A to position A.

(11) Make an approximate measurement of the crystal frequency. This may be done by connecting cable assembly W1 from J5 to a radio receiver with the bfo turned on.

(12) Set the decade resistors to the maximum resistance specified in the pertinent crystal data sheet for the particular crystal under test.

(13) Switch the CALIBRATE—CRYSTAL switch to the CALIBRATE position. If the GRID CURRENT meter goes off scale, immediately switch enough resistance (by means of the decade resistors) into the circuit to bring the GRID CURRENT meter reading back to the setting obtained in the CRYSTAL position.

(14) Adjust the TUNING control so that the signal is at zero beat with the frequency measured in (11) above.

(15) Switch the CALIBRATE CRYSTAL switch to the CRYSTAL position.

(16) Adjust the GRID CURRENT control to obtain any convenient value of meter reading. This adjustment must remain fixed throughout the remainder of the test.

(17) Move the CALIBRATE—CRYSTAL switch to the CALIBRATE position.

(18) Adjust the decade resistor to obtain the same value of GRID CURRENT meter reading as when the CALIBRATE—CRYSTAL switch was in the CRYSTAL position.

(19) Readjust the TUNING control to obtain the same frequency that prevailed in the CRYSTAL position.

(20) Repeat the steps outlined in (18 and (19) above, if necessary, to obtain identical grid current and frequency values in both the CALIBRATE and CRYSTAL positions.

(21) Read the value of resistance from the settings of the decade resistors. This is the effective antiresonant resistance of the crystal unit.

(22) Move the CALIBRATE—CRYSTAL switch to CRYSTAL position. Make an accurate measurement of the operating frequency (a(20) above). This value is the antiresonant frequency.

c. PROCEDURE FOR USING CI METER AS A GO-NO-GO GAGE, ANTIRESONANT OPERATION.

(1) Insert the a-c cable assembly (W2) plug PI into a 115-volt, 50- to 1,720-cps, a-c source.

(2) Throw the ON-OFF switch to ON. Allow 15 minutes for the equipment to warm up.

(3) Adjust the crystal drive (crystal wattage rating) according to information given in the specification covering the particular crystal unit under test. Where no drive level has been established, the crystal should be maintained at as low a level as possible. To accomplish this, advance the GRID CURRENT control to its extreme clockwise position, and then advance the CRYSTAL CURRENT control to that position which will give a convenient GRID CURRENT meter reading.

(4) Turn the S—A switch to the A position.

(5) Adjust the LOAD CAPACITY dial to the proper setting. Calibration data are given in the calibration chart (par. 13) supplied with the instrument.

(6) Turn the KILOCYCLES switch to the frequency range of the crystal.

(7) Move the CALIBRATE—CRYSTAL switch to the CRYSTAL position.

(8) Insert the crystal unit in the crystal socket.

(9) Adjust the TUNING control for a maximum GRID CURRENT meter reading. It may be necessary to adjust the GRID CURRENT control in order to obtain a convenient GRID CURRENT meter reading.

Caution: Do not disturb the CRYSTAL CURRENT control; this must remain fixed ((3) above) for the remainder of the test.

(10) Make an approximate measurement of the crystal frequency. This may be done by connecting cable assembly W1 from J5 to a radio receiver with the bfo turned on.

(11) Move the CALIBRATE—CRYSTAL switch to the CALIBRATE position.

(12) Adjust the decade resistors to the value which corresponds with the maximum permissible resistance for the frequency desired, as indicated in the applicable crystal unit specification.

(13) Adjust the TUNING control so that the signal is at or near zero beat with the frequency measured in (10) above.

(14) Adjust the GRID CURRENT control to obtain any convenient value of GRID CURRENT meter reading. This adjustment must remain fixed throughout the remainder of the test.

(15) Note the GRID CURRENT value. This value is the passing activity level.

(16) Move the CALIBRATE—CRYSTAL switch to the CRYSTAL position.

(17) Crystals exhibiting a greater GRID CURRENT meter reading than that obtained in (15) above pass the activity requirements; those showing less, fail.

(18) The above procedure must be repeated each time the crystal unit frequency is changed.

d. Procedure for Using CI Meter as a Go-No-Go Gage, Series-Resonant Operation.

(1) Insert the a-c cable assembly (W2) plug PI into a 115-volt, 50- to 1,720-cps, a-c source.

(2) Switch the ON-OFF switch to ON. Allow 15 minutes for the equipment to warm up.

(3) Adjust the crystal drive according to information given in the specification covering the particular crystal unit under test. Where no drive level has been established, the crystal should be maintained at as low a level as possible. To accomplish this, advance the GRID CURRENT control to its extreme clockwise position, and then advance the CRYSTAL CURRENT control to that position which will give an adequate current reading.

(4) Turn the S—A switch to the S position.

(5) Turn the KILOCYCLES switch to the proper frequency range.

(6) Move the CALIBRATE—CRYSTAL switch to the CRYSTAL position.

(7) Insert the crystal unit in the crystal socket.

(8) Adjust the TUNING control for maximum GRID CURRENT meter reading. It may be necessary to adjust the GRID CURRENT control in order to obtain a convenient GRID CURRENT meter reading.

Caution: Do not disturb the CRYSTAL CURRENT control; this control must remain fixed ((3) above) for the remainder of the test.

(9) Make an approximate measurement of the crystal frequency by connecting cable assembly W1 from J5 to a radio receiver with the bfo turned on.

(10) Move the CALIBRATE—CRYSTAL switch to the CALIBRATE position.

(11) Adjust the decade resistors to the value which corresponds to the maximum permissible resistance for the frequency desired, as indicated in the applicable crystal unit specification.

(12) Adjust the TUNING control so that the signal is at or near zero beat with the frequency measured in (9) above.

(13) Adjust the GRID CURRENT control to obtain any convenient value of GRID CURRENT meter reading. This adjustment must remain fixed throughout the remainder of the test.

(14) Note the GRID CURRENT value. This value is the passing activity level.

(15) Move the CALIBRATE—CRYSTAL switch to CRYSTAL position.

(16) Crystals exhibiting a greater GRID CURRENT meter reading than that obtained in (14) above, pass the activity requirements; those showing less, fail.

(17) The procedure outlined must be repeated each time the crystal unit frequency is changed.

e. Operating Instructions for Using CI Meter With Crystal Test Block at Antiresonance. For temperature-cycling individual crystals operating at antiresonance with a given value of load capacitance, use a test block, or equivalent, containing a padding capacitor mounted in series with one of the crystal leads (see TM 11–2540). Proceed as follows:

(1) Find the exact frequency of the crystal unit under test, as outlined in the antiresonant test procedure in *b* above.

(2) Remove the crystal from the socket and insert it in the test block. Insert the test block in the crystal socket.

(3) Turn the S—A switch to the S position.

(4) Adjust the trimmer capacitor in the crystal test block until the frequency of the crystal is precisely the same as the frequency found in (1) above. The test block is now ready for operation.

f. Operating Instructions for Using CI Meter With Crystal Test Block at Series Resonance. If it is desired to temperature-cycle individual crystals operating at series resonance, use a temperature test block without a series padding capacitor. Proceed as follows:

(1) Insert the crystal test block in the crystal socket.

(2) Turn switch S—A to position S.

(3) Insert the crystal in the test block. The block is now ready for use.

13. Calibration Chart for LOAD CAPACITY Dial

The LOAD CAPACITY dial (I–2) is marked with numbers from 0 to 100. These markings can be translated into $\mu\mu$f by utilizing a chart (fig. 4) supplied with each equipment. This chart is prepared specially for the particular CI meter; *see that the serial number on the chart corresponds with that on the equipment.* To obtain the value of load capacity in $\mu\mu$f, proceed as follows:

a. Locate the dial setting on the abscissa (point A) of the chart (A, fig. 4).

b. Trace this value to the curve.

c. Find the equivalent ordinate value (B, fig. 4). This is the value of load capacitance in $\mu\mu$f.

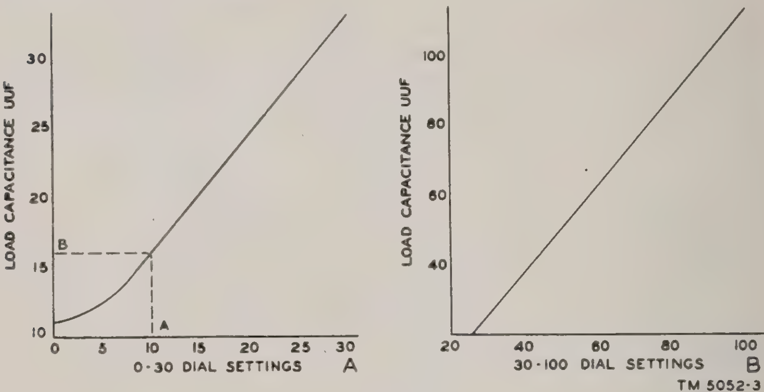


Figure 4. Calibration chart for determination of load capacitance from dial settings.

14. Crystal Parameters

a. GENERAL.

(1) *Piezoelectric effect.* When an electric stress is applied to a cut quartz crystal in the direction of one of the major axes, a mechanical stress is produced at right angles to this axis. Conversely, a mechanical stress along a major axis will cause electrical charges to appear on the faces of the crystal perpendicular to the stress axis. The polarity of the electric stress and the direction of the corresponding mechanical force are interrelated; a reversal in one causes a reversal in the other. This relationship between electrical stress and mechanical force is termed the piezoelectric effect and provides a means of relating mechanical vibrations to electrical circuits.

(2) *Resonance.* An alternating voltage applied across a quartz crystal will cause the crystal to vibrate; if the frequency of an applied alternating voltage approximates a frequency at which mechanical resonance can exist in the crystal, the amplitude of the vibrations will be very large. Any crystal has several such resonant frequencies that depend on the crystal dimensions, the type of oscillation involved, and the orientation of the plate cut from the natural crystal.

(3) *Properties of piezoelectric resonator.* A good piezoelectric resonator possesses the following properties: a low-temperature coefficient of resonant frequency, a high piezoelectric activity (performance index), and a frequency spectrum containing only one resonant frequency in the vicinity of the desired oscillation. Temperature can alter the frequency of mechanical resonance through its effects on the density, the linear dimensions, and the moduli of elasticity of the crystal. Since some of the elastic constants are positive, while others are negative, the temperature coefficient of frequency may be either positive, negative, or zero, according to the mode of oscillation, the orientation of the crystal plate, and the shape of the plate. The electrical circuit associated with a vibrating crystal is shown in figure 5. The capacity, C_o, represents the electrostatic capacity between the crystal electrodes when the crystal is in place but not vibrating; the series combination of L, C, and R represents the equivalent mass, compliance, and frictional loss of the vibrating crystal, respectively. Read TM 11–2540 for more detailed information in this subject.

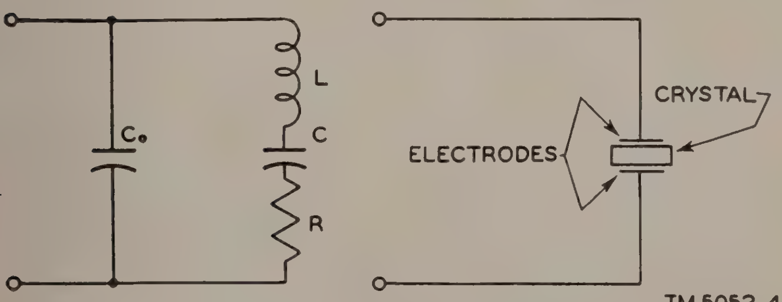


Figure 5. Equivalent electrical circuit of a piezoelectric crystal.

b. MEASUREMENT.

(1) *Static capacitance C_o.* The value of the static capacitance of the crystal unit, C_o, may be measured by any conventional

capacitance measuring unit. If this measurement is made by using a Q meter or an r-f bridge, be careful to select a frequency of operation somewhat lower than the crystal unit frequency. Figure 5 shows a diagram of the parameters of a piezoelectric crystal.

(2) *Series-resonant and antiresonant resistances.* The measurement of the effective resistance in ohms at series resonance is outlined in the operational procedure (par. 12*a*). The measurement of effective resistance in ohms at antiresonance is outlined in the operational procedure (par. 12*b*).

(3) *Series capacitance, C.* Use the following equation to calculate the capacity, C, of the series arm of the crystal:

$$C \text{ (in farads)} = \frac{2\ (C_o + C_1)\ \triangle F}{F}$$

where: $\triangle F$ = the difference between the antiresonant frequency and the series resonant frequency ($F_a - F_s$) in cps,
F = the nominal frequency of the crystal unit in cps,
C_o = the static capacitance of the crystal unit in farads, and
C_1 = the load capacitance in farads.

(4) *Inductance, L.* Use the following equation to calculate the inductance, L, in the series arm of the crystal:

$$L \text{ (in henries)} = \frac{1}{(2\pi\ F)\ 2_C}$$

where: F = the nominal frequency of the crystal unit in cps, and
C = series capacitance, C, of the crystal unit in farads.

(5) *Voltage across the crystal unit.* Two pairs of receptacles are provided on the front panel for the measurement of voltage across the crystal unit. Two vacuum-tube voltmeters, such as Electronic Multimeter TS–505/U, may be used for this measurement. The r-f current through the crystal unit also may be determined. Series resonance and antiresonance present two different cases, as follows:

(*a*) *Series resonance.*

$$E = E_d = IR;\ I = \frac{E_d}{R}$$

where: E = the voltage across the crystal unit in volts,
E_d = difference between the two voltmeter readings,

R = effective series-resonant resistance in ohms (par. 12*a*), and
I = r-f crystal current in amperes.

(*b*) *Antiresonant resistance.*

$$E = \frac{E_d}{2\pi \ FC_1 \ R_e} = \frac{I}{2\pi \ FC_1}$$

where: F = nominal frequency of the crystal unit in cps,
C_1 = load capacitance in farads, and
R_e = effective antiresonant resistance in ohms (par. 12*b*).

(6) *Performance index, (PI).* The PI of the crystal unit also may be calculated from the following equation:

$$PI = \frac{X_e^2}{R_e} = \frac{1}{(2\pi \ FC_1)^2 \ R_e}$$

where:

$$X_e = \frac{1}{2\pi \ FC_1}$$

15. Equipment Performance Checklist

a. General. The equipment performance checklist aids in determining whether Crystal Impedance Meter TS–537/TSM is functioning properly. This checklist gives the item to be checked, the action or condition under which it is checked, the normal indications of correct operation (what should happen), and the corrective measures (what to do) the operator may take.

b. Action or Condition. The information in the *Action or Condition* column represents an action that must be taken to check the normal indication given in the *Normal indication* column.

c. Normal Indication. The normal indications listed include the visible signs the operator will find when he checks the items. Apply the recommended corrective measures if the indications are not normal.

d. Corrective Measure. When normal indications are not present, the operator may perform the corrective measures listed without turning the equipment in for repairs. If the set is completely inoperative or if the recommended corrective measures do not yield results, refer to chapter 5.

e. CHECKLIST.

Item No.	Item	Action or condition	Normal indication	Corrective measure
1	ON-OFF switch (S8).	Turn Switch to ON position.	Pilot lamp lights	See that the power cable (W2) is connected to the proper power source. Check fuse. Check lamp.
2	CALIBRATE—CRYSTAL switch (S7).	Set at the CALIBRATE position. Increase CRYSTAL CURRENT control. See that KILOCYCLES knob is not on the COIL position. Increase GRID CURRENT control. Set decade resistor switches (S1, S2) at zero.	GRID CURRENT meter indication.	See chapter 5, section III, trouble shooting.
3	KILOCYCLES switch (S5).	Switch to each successive range.	GRID CURRENT meter indication.	See chapter 5, section III, trouble shooting.
4	TUNING control (C1).	Rotate for each position of the KILOCYCLES switch.	GRID CURRENT meter indication.	See chapter 5, section III, trouble shooting.
5	Decade resistor switches (S1, S2) and range toggle switches (S3, S4).	Rotate clockwise switches S1 and S2 and throw toggle switches to increase resistance. Decrease resistance.......	Decrease in grid current for any position of items 3 and 4. Increase in grid current for any position of items 3 and 4.	See chapter 5, section III, trouble shooting.
6	CRYSTAL CURRENT control (R42).	Rotate clockwise (GRID CURRENT control must be slightly advanced).	Increase in GRID CURRENT meter indication.	See chapter 5, section III, trouble shooting.
7	GRID CURRENT control (R41).	Rotate clockwise (CRYSTAL CURRENT control can be set in any position).	Increase in GRID CURRENT meter indication.	See chapter 5, section III, trouble shooting.
8	Vacuum tube voltmeter receptacles H and L (J1, J2, J3, J4).	Insert voltmeter plugs..... Increase both CRYSTAL CURRENT and GRID CURRENT controls slightly.	Voltage indication voltmeter.	Check vacuum-tube voltmeter. See chapter 5, section III, trouble shooting.
9	R-f cable assembly (W1).	Connect to frequency measuring equipment.	Detect beat notes...	Check cable for continuity.

Item No.	Item	Action or condition	Normal indication	Corrective measure
10	CALIBRATE—CRYSTAL switch (S7).	Set at the CRYSTAL position. Turn decade resistor switches to the 0 positions. Rotate the CRYSTAL CURRENT and GRID CURRENT controls to the maximum INCREASE positions. Turn S—A switch to the S position. Rotate the TUNING control completely for each range setting of the KILOCYCLES switch.	No GRID CURRENT meter indication.	See chapter 5, section III, trouble shooting.
11	Crystal socket	Insert a resistor of approximately 10 ohms. Leave all controls as set in item No. 10. Adjust GRID CURRENT control to prevent excessive needle deflection on GRID CURRENT meter.	GRID CURRENT meter indication.	Make a continuity check of the crystal socket.

16. Operation under Unusual Conditions

Operation of Crystal Impedance Meter TS–537/TSM in tropical, arctic, or desert regions, where extremes of temperature and humidity often occur, involves problems which require special care of the equipment. In most cases, this special care must be determined by the particular installation and resultant degree of exposure to these severe conditions. For information covering the special treatment of equipment subject to these conditions, refer to chapter 3, section I.

CHAPTER 3

MAINTENANCE INSTRUCTIONS

Section I. PRESERVATION

Note. Lubrication is not required; the rotating parts are constructed so that further lubrication is unnecessary.

17. Weatherproofing

a. GENERAL. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. TROPICAL MAINTENANCE. A special moistureproofing and fungiproofing treatment has been devised, which, if properly applied, provides a reasonable degree of protection. This treatment is explained fully in TB SIG 13 and TB SIG 72.

c. WINTER MAINTENANCE. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained fully in TB SIG 66 and TB SIG 219.

d. DESERT MAINTENANCE. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained fully in TB SIG 75.

18. Rustproofing and Painting

a. Whenever the finish on the cabinet has been scarred or damaged badly, touch up the bared surface to prevent rust and corrosion. Use No. 00 or No. 000 sandpaper to clean the surface down to the bare metal and obtain a bright smooth finish. For severe rust, use Solvent, dry-cleaning (SD), to soften the rust and then use sandpaper to remove it.

Caution: Do not use steel wool or emery cloth instead of sandpaper because minute particles of conducting material may enter the cabinet and cause shorting or grounding of circuits.

b. Before repainting, touch up bared metal parts with a primer coat and allow it to dry. When a touch-up is needed, apply paint with a small brush. Do not remove any electrical parts in order to accomplish the painting.

Section II. PREVENTIVE MAINTENANCE SERVICES

19. Definition and Importance

a. Definition. Preventive maintenance is a systematic series of operations performed at regular intervals on equipment to minimize major breakdowns and unwanted interruptions in service and to maintain equipment at top operating efficiency. Preventive maintenance differs from trouble shooting and repair since its object is to prevent breakdowns and the resulting need for trouble shooting and repair.

b. Importance. Through these systematic inspections, personnel charged with the care of the equipment should be able to detect abnormal conditions and possible sources of trouble and correct them before major troubles or breakdowns occur.

20. Tools and Materials

The tools and materials listed below are used in performing preventive maintenance on Crystal Impedance Meter TS–537/TSM and must be on hand before preventive maintenance action is taken.

Signal Corps stock No. (unless otherwise specified)	Name and description
6Z7500-0000	Abrasive, sheet: sandpaper; grit size 4/0; 9″ x 10″.
6G184.1	Carbon tetrachloride: 8-oz. metal container.
6N1624	Cloth, textile: 9⅜″ squares; cleaning.
	Common hand tools.
6G1516	Polish: paste; 2-oz container.
51–S–4385–1 (QMC)	Solvent, dry-cleaning (SD).

Note. Gasoline will not be used as a cleaning fluid for any purpose.

21. Preventive Maintanence Techniques

a. Use No. 0000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) If necessary, except for electrical contacts, moisten the cloth or brush with solvent (SD); then wipe the parts dry with a cloth.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a dry cloth.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 (pounds per square inch) to remove dust from inaccessible places; be careful, however, or mechanical damage from the air blast may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 123.

22. Preventive Maintenance Checklist

The following checklist is a summary of the preventive maintenance operations that must be performed on Crystal Impedance Meter TS–537/TSM. The list indicates what to check, when to check, how to check, and what precautions to take before, during, and after checking the equipment.

Item No.	What to check	When to check*	How to check	Precautions
1	CI meter exterior and panel.	D	Inspect for damage, chipped paint, dirt, dust, rust, corrosion, and loose or missing screws. Wipe with a clean cloth slightly moistened with solvent (SD) to remove oil, grease, or foreign matter. Wipe with a dry cloth.	Tighten screws snugly; never force them.
2	Connector receptacles J1, J2, J3, and J4.	W	Lift out operating panel from case by taking out the three mounting screws. Inspect the receptacles for dirt, dust, and other foreign matter. Be sure receptacles are fastened tightly. Clean with solvent (SD) and a clean dry cloth.	Do not tighten jack screws more than necessary; never force them.
3	Controls......	D	Inspect for freedom of action. See that only a normal amount of pressure is required to operate them. Be certain knobs are not loose.	Do not overtighten screws holding knobs.
4	Interior......	M	Inspect wiring and other parts for defects. Check contacts of keys and switches for dirt, dust, or foreign matter. Look for corrosion and rust. See that all solder joints are secure. Check screws, nuts, and bolts. Tighten screw-type terminals. Blow dust or dirt from interior with an air hose.	Do not overtighten screws, nuts, and bolts. If it is necessary to resolder, be sure no loose solder falls between other parts; this causes shorts.
5	Cable assemblies and plugs.	W	Inspect cable assemblies for dirt, dust, mildew, and fungus growth. Inspect plugs for corrosion and loose connections. Clean cable assemblies with a clean dry cloth; wipe off dirt, dust, and foreign matter. If grease is on cable assemblies, use solvent (SD). Clean plugs with polish.	Never use soap and water when cleaning cable assemblies and plugs. Never use gasoline.
6	Switch contacts.	M	After a prolonged period of inactivity, the switch contacts may become corroded. Clean them with sandpaper # 0000.	Do not use emery cloth; the abrasive particles are conductive.

*D—Daily; W—Weekly; M—Monthly.

CHAPTER 4

AUXILIARY EQUIPMENT

23. Frequency Measuring Equipment

a. STANDARD FREQUENCY TEST RACK. The CI meter may be coupled to a standard frequency test rack (fig. 6), or other similar equipment, to measure the exact frequency of crystal units. The standard frequency test rack consists of the items listed below; other frequency test equipment consists of similar items.

(1) Bfo radio receiver.

(2) Selected reactor (and its associated coil graph) for use in the bfo receiver.

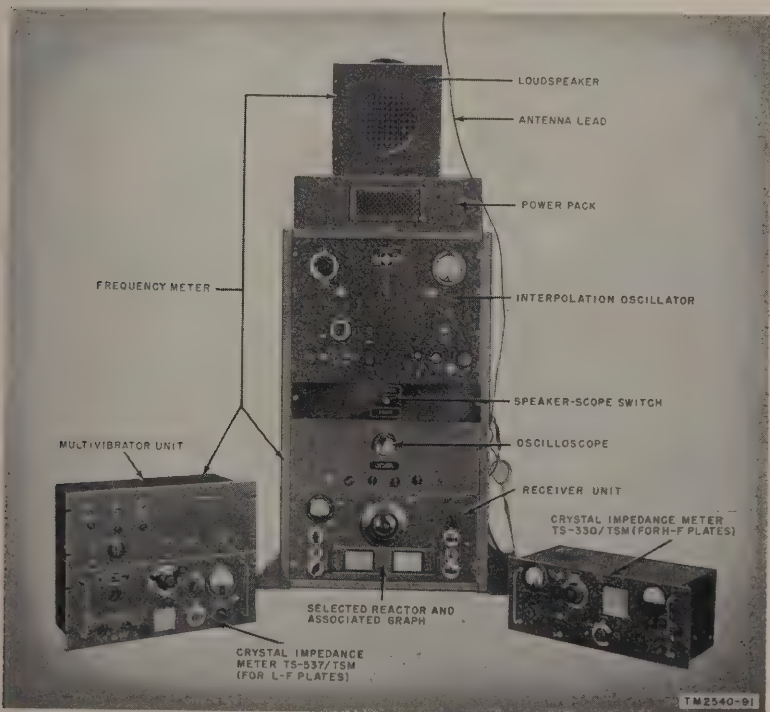


Figure 6. Crystal resistance and frequency measuring equipment.

(3) Oscilloscope.

(4) Interpolation oscillator.

(5) Power pack.

(6) Loudspeaker.

(7) Multivibrator unit (secondary standard).

(8) Antenna.

(9) Power supply.

b. ALTERNATE EQUIPMENT. Alternate frequency measuring equipment may be used in place of that listed in *a* above, but with less accurate results.

(1) A calibrated radio receiver may be used. The degree of accuracy will be low, however, because of the frequency variation that commonly is found in such radio circuits.

(2) Frequency Meter Set SCR–211 may be used in an emergency to supply the frequency standard in place of the multivibrator unit or interpolation oscillator. Its main function, however, is to tune and calibrate radio receivers in a net to a given frequency.

(3) A comparison oscillator and deviation meter may be substituted for the interpolation oscillator. Relatively poor frequency stability and accuracy of calibration make this equipment less desirable than the interpolation oscillator.

24. Procedure for Measuring Accurate Frequencies

The frequency of crystal units can be determined accurately by coupling the CI meter to a standard frequency test rack (fig. 6), Frequency Measuring Assembly CY–93/FSM–1, or similar frequency measuring equipment. Operating procedure will vary according to the equipment used, but is essentially as follows: The crystal unit is inserted into the CI meter which is coupled to the frequency test equipment by means of a coaxial cable (W1) connected to the antenna of the bfo of the radio receiver. The receiver is adjusted for c-w (continuous-wave) operation, and the crystal unit is tuned in; the dial setting is noted. The crystal unit then is turned off, and the receiver is tuned to the standard signal nearest the above dial setting. The bfo in the receiver then is turned off, and the CI meter with the crystal unit under test is turned on. The audio beat note then is measured by means of the audio (or interpolation) oscillator and the loudspeaker or oscilloscope. (Read TM 11–2540 for detailed information on beat notes.) If the loudspeaker is used, the audio beat note is noted by ear. If the oscilloscope is used, the audio oscillator is set to deliver a signal to the scope. A fluttering image will be seen on the screen of the oscilloscope when the two frequencies are nearly

the same. This image changes to a circular one as the audio generator frequency is varied slowly and is made the same as the beat-note frequency. When the circular image is secured, the beat frequency can be read on the calibrated scale of the interpolation oscillator. The beat-note measurement is added to or subtracted from the frequency of the interpolation oscillator signal in order to get the exact frequency of the crystal unit under test. To determine whether the frequency of the audio beat note is to be added or subtracted, capacity is added to the crystal unit to lower the frequency of the crystal unit. If the audio beat note increases in pitch, then it is known that the frequency difference between the two signals is increased and that the frequency of the crystal is below that of the standard. Therefore, the frequency of the audio beat note is subtracted from the standard signal. However, if the audio beat note decreases in pitch, then it is known that the frequency difference between the two signals has become smaller and that the frequency of the crystal unit is higher than that of the standard. The frequency of the audio beat note then is added to the standard frequency.

25. References

For detailed information on frequency test equipment, refer to the following publications:

TM 11–2540	Quartz Crystals—Theory, Fabrication, and Performance Measurements.
TM 11–2530	Frequency Standard TS–308/U.
TM 11–2606	Test Set AN/FSM–3, Tool Equipment TK–40/FSM–3, and Maintenance Kit MK–40/FMS–3 (Formerly Depot Crystal Equipment AN/FSM–1).
TM 11–5051	Crystal Impedance Meter TS–330/TSM.

CHAPTER 5

FIELD MAINTENANCE INSTRUCTIONS

Section I. THEORY OF OPERATION

26. General

Crystal Impedance Meter TS–537/TSM measures the equivalent impedances of a piezoelectric crystal in the frequency range of 75 to 1,100 kc. The equipment consists of a single r-f pentode tube oscillator, a feedback network, and a conventional power supply. The crystal under test or a decade resistor can be made a part of the feedback network. The magnitude of the voltage oscillations of the tube is indicated by the GRID CURRENT meter. For a general analysis of the interrelationship of the components, refer to figure 7.

27. Functioning of Crystal Impedance Meter TS–537/TSM

a. General.

(1) The crystal impedance meter is essentially a tuned-grid tuned-plate oscillator circuit (fig. 8) in which the crystal unit to be tested is placed in the feedback path. The crystal unit thus controls the oscillation frequency of the circuit and the amplitude of oscillation. The effective resistance of the crystal unit then is measured by application of the following principle of substitution: In any system, if an element of the system is removed a substitute element is inserted in its place so that the original set of boundary conditions is satisfied and no new ones are added, then the substitute element is operationally equivalent to the original element. Thus, the boundary conditions (oscillation frequency and amplitude of oscillation) are measured at some point in the circuit; a network of resistance and reactance is substituted for the crystal unit without changing the boundary conditions; then the network represents the crystal unit at that particular frequency and amplitude of oscillation. The crystal unit may be operated at either series-resonant frequency or at anti-resonant frequency.

(2) At series resonance, the equivalent electrical circuit (fig. 5) of the crystal unit is purely resistive. At antiresonance,

the equivalent electrical circuit of the crystal unit is inductive. Thus, when the crystal unit is operated at antiresonant frequency and the correct value of load capacitance (C_1) is connected in series with the crystal unit, then, at the correct operating frequency, the combination of crystal unit and load capacitance appears as a pure resistance. Therefore, in either case, a resistance may be substituted for the crystal unit or for the combination of the crystal unit and load capacitance; this resistance can be adjusted to such a value that the oscillation frequency and amplitude are the same as they were before the substitution was made. This value of resistance is, therefore, the effective series-resonant resistance (R) or the effective anti-resonant resistance (R_e), as the case may be.

(3) In actual use, neither the series-resonant nor anti-resonant frequency may be known; this information, however, is not necessary. The circuit of the CI meter (connected to appro-

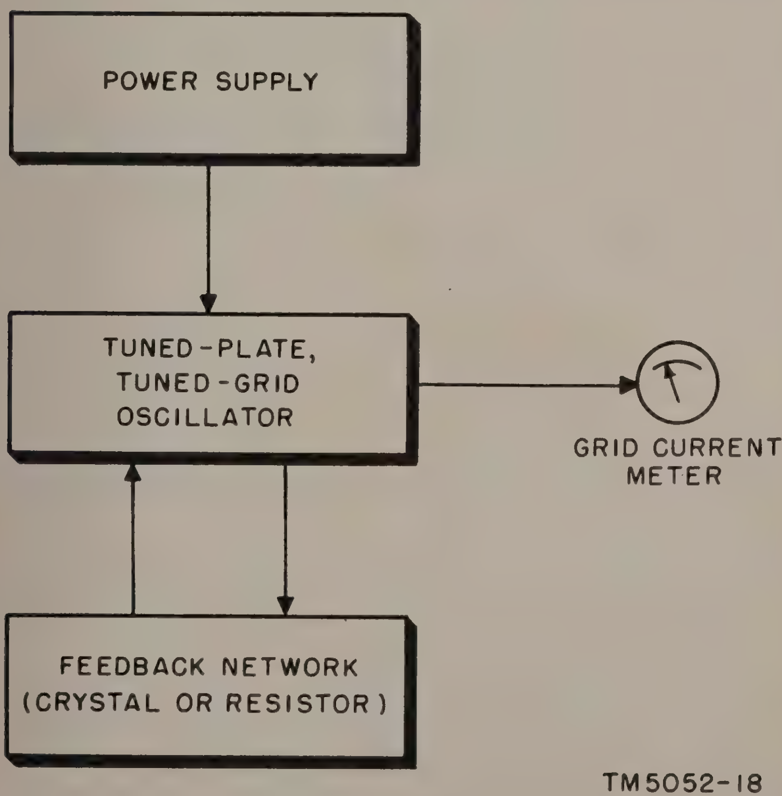


Figure 7. Block diagram.

priate frequency measuring equipment (fig. 6)) first is tuned to the appropriate frequency; then, by alternate adjustment of the value of the substitution resistance and of the circuit tuning, the correct frequency and value of resistance are obtained. Generally, this cycle of adjustment must be made only two or three times before complete satisfaction of the boundary conditions is attained. These adjustments may be compared with the resistance and reactance adjustments performed in balancing an impedance bridge.

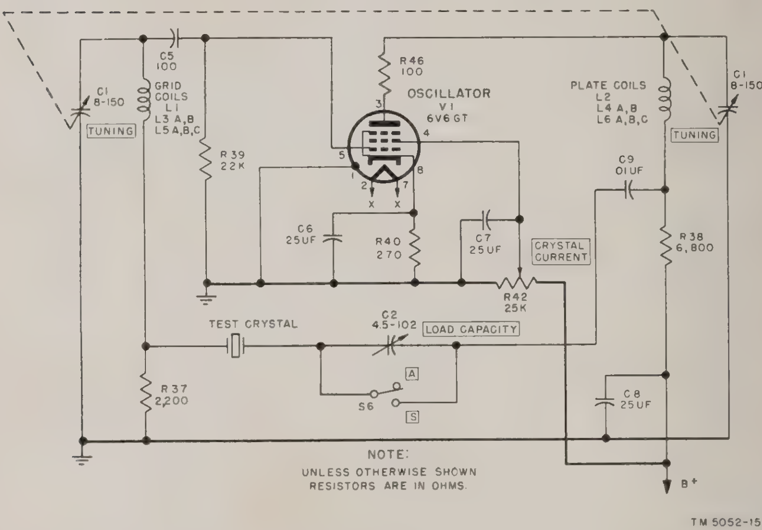


Figure 8. Simplified over-all schematic diagram.

b. POWER SUPPLY.

(1) The power supply (fig. 9) is a conventional type that converts a-c 115 volts, 50 to 1,720 cps, to the regulated d-c (direct-current) voltage necessary for the plate and screen grid of oscillator tube V1. The power supply uses rectifier tube V2 (5Y3GT) in a full-wave rectifier circuit and tubes V3 and V4 (type OC3W) as voltage regulators. Input fuse F1, rated at 1 ampere 250 volts, opens the line if an overload or short occurs inside the CI meter. ON-OFF power switch S8 breaks one side of the a-c line.

(2) Transformer T1 has a primary rating of 115 a-c volt, single-phase, with output windings on the secondary of 700 volts at 35 ma (milliamperes) center-tapped for the plates of V2 (rectifier tube 5Y3GT), 5.0 volts at 3.0 amperes for the

filament of V2, and 6.3 volts at 2.5 amperes for the filament of V1 (oscillator tube 6V6GT) and pilot lamp E1.

(3) The ripples are filtered out of the rectified output of V2 by resistors R43 and R44 and two-section capacitor C11. These filters are connected to voltage-dropping resistor R45 which, in turn, is connected to voltage-regulating tube V3. Tube V3, operating in conjunction with resistor R45, maintains a constant voltage of 105 volts across its terminals despite normal changes in line voltage and current drain of the connected circuits. Should the voltage across this gaseous regulator rise, the tube would draw more current, cause a greater voltage drop across R45, and, consequently, keep the voltage at the plate (pin 5) of V3 constant. Should the voltage drop, less current will be drawn by V3; thus, the voltage across R45 will be smaller and the voltage at the plate of V3 will be kept constant.

(4) Voltage regulators V3 and V4 are connected in series to maintain a sufficiently high d-c voltage (approximately 210 volts) for the plate of the oscillator tube V1. The screen grid of tube V1 is supplied with d-c voltage controlled by potentiometer R42 (CRYSTAL CURRENT control) connected across the voltage regulator tube V4. This screen grid voltage controls the amplitude of r-f oscillations. The .003 μf (microfarad) capacitor C12 bypasses r-f current from the input a-c power line to ground. The .25 μf capacitor C8 prevents r-f current of the plate circuit from flowing in the power supply circuit.

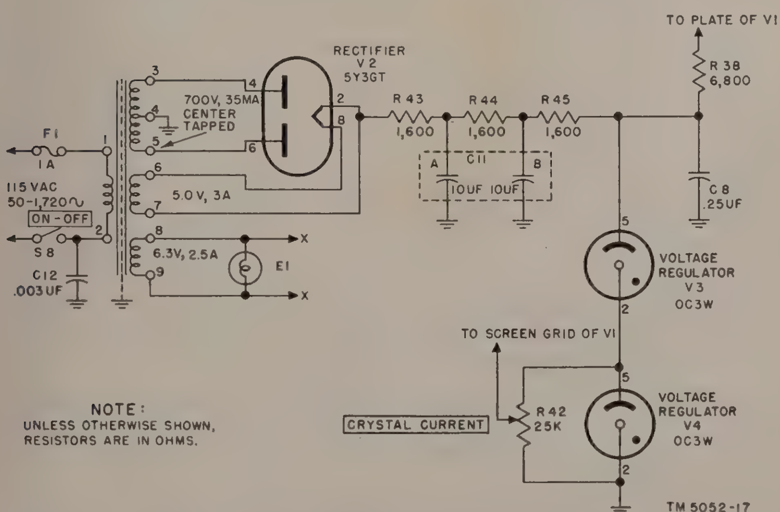


Figure 9. Power supply, schematic diagram.

c. Oscillator Circuit.

(1) The oscillator circuit (fig. 10) has a beam power vacuum tube V1 (6V6GT) operating as a class C amplifier. The feedback path provided by either the crystal or the decade resistor causes the circuit to operate as a class C oscillator. Any one of six frequency bands may be selected by switching (with two-section switch S5) r-f coils L2, L4A, L4B, L6A, L6B, and L6C into the plate circuit and corresponding r-f coils L1, L3A, L3B, L5A, L5B, and L5C into the grid circuit of tube V1. For each band, the plate coil has the same inductance as the grid coil. Sockets X5 and X6 are provided for plug-in grid and plate coils to extend the range of the CI meter downward. The frequency range covered is 75 to 1,100 kc in six ranges. Each band is tuned by varying dual section capacitor C1 (TUNING), of value 8 to 15 $\mu\mu$f each section. Receptacle J5 is connected to the plate circuit by a capacitive coupling consisting of a minimum of 2½ turns of insulated wire wound around the plate lead (fig. 12).

(2) When the control grid (pin 5) is driven positive during a cycle of oscillation, rectified d-c flows through the 20,000-ohm grid leak resistor R39, GRID CURRENT meter M1 (the sensitivity of which is adjusted by potentiometer R1 (GRID CURRENT control)), and to ground. The 100-$\mu\mu$f capacitor C5 blocks the rectified control grid current from flowing in r-f coils L1, L3A, L3B, L5A, L5B, and L5C. The magnitude of oscillation is controlled by varying the voltage on the screen grid of V1 with 25,000-ohm potentiometer R42 (CRYSTAL CURRENT control) connected across voltage regulator tube V4. The .25 μf capacitor C7 decouples the screen grid (pin 4) of V1 and by passes r-f current to ground. The cathode (pin 8) is connected to the cathode bias resistor R40 in parallel with bias capacitor C6. Variable capacitor C13 is connected between the control grid and ground to compensate for the effect of stray wiring capacitance.

d. Feedback Network. The feedback network (figs. 8 and 10) has two sections: the crystal socket assembly and the resistance substitution decade. Lever switch S7 (CALIBRATE—CRYSTAL) connects either one section or the other into the feedback path. The .01-μf capacitor C9 provides a low-impedance path for the r-f voltage developed across resistor R38 by the r-f current generated in the tuned-plate tank circuit of tube V1. Capacitor C9 also provides the necessary phase relation for the r-f voltage feedback to the grid circuit. The feedback voltage is injected into the grid circuit across

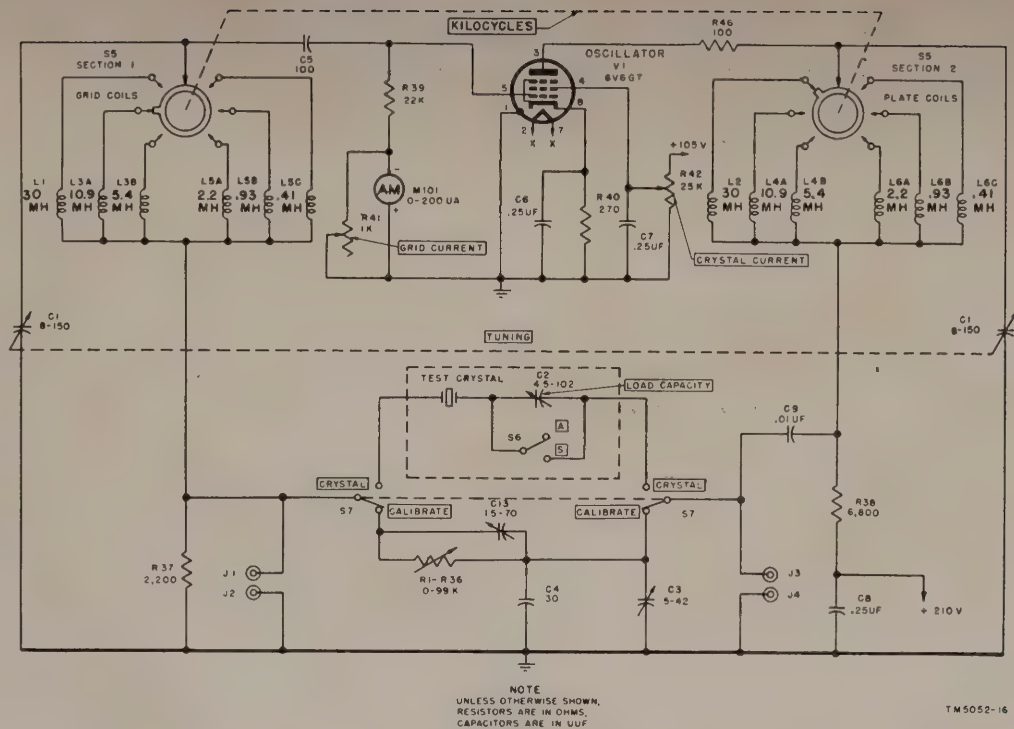


Figure 10. Oscillator and feedback circuits.

the voltage dividing resistor R37. Switch S6 (S A) is mounted in the crystal socket assembly and short-circuits the 4.5- to 102-$\mu\mu$f variable capacitor C2 (LOAD CAPACITY) for series-resonant tests on crystals. The resistance substitution network consists of resistors R1 through R36; decade resistor switches S1 and S2 and toggle switches S3 and S4 select the substitution resistance from 0 to 99,000 ohms in 10-, 100-, and 1,000-ohm steps. The resistance decades are switched into the oscillator circuit and adjusted to obtain the same amplitude of oscillation as the oscillating crystal unit. The switch positions of the decades then indicate the resistance. The fixed 30-$\mu\mu$f capacitor C4 and the variable 5- to 42-$\mu\mu$f capacitor C3 are connected between the resistance decades and ground and compensate for the capacitance of the crystal socket assembly to ground. The crystal socket assembly and the box shield around it are insulated from ground. The crystal socket assembly will accommodate any two-pin crystal unit with a center-to-center pin spacing of .5 inch to 1.25 inches; crystal holders similar to Crystal Holder FT-249 may be tested. The crystal socket assembly adds a minimum of capacitance across the crystal.

Section II. PREREPAIR PROCEDURES

Note. This section contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by skill of the repairman.

28. Tools, Materials, and Test Equipment

Tools, materials, and test equipment needed for performing the prerepair procedures in this section are listed below:

Common hand tools.
Electronic Multimeter TS-505/U.
Multimeter TS-352/U.
Tube Puller TS-201.
Tube Tester I-177, I-177-A, or I-177-B.

29. Removal of Pluck-Out Parts

a. TUBES.

(1) Remove the cover from the equipment by unscrewing the No. 6-32 screws around the top, sides, and back.

(2) Use Tube Puller TS-201 to remove the tubes (fig. 11) from their sockets. If the space around the tube is limited so that the tube puller cannot be used, pull out the tubes with the fingers; however, first be sure that the tubes have cooled sufficiently. Do not rock the tube or jiggle it in its socket

if it can be extracted by a direct upward pull. Rock it *gently* if it does not release easily. Jiggling a tube in its socket during removal spreads the contacts. Label each tube as soon as it is removed so that it can be replaced later in its proper socket.

b. FUSE. Remove fuse F1 by turning fuseholder E3 on the back of the chassis (fig. 11) counterclockwise. Pull the cartridge fuse out of the cover.

c. LAMP. Unscrew the jewel guard of the light indicator (I-1) on the front panel (fig. 3) and remove the bayonet-base lamp (E1) by pushing it in and turning it clockwise.

30. Cleaning, Inspecting, and Testing Pluck-Out Parts

a. CLEANING, INSPECTING, AND TESTING TUBES.

(1) *Cleaning.* Clean the tubes with a cloth moistened with solvent (SD). If necessary, clean the prongs with crocus cloth.

(2) *Inspecting.* Inspect the tubes for cracks in glass and base and for bent and broken prongs.

(3) *Testing.* Test the tubes for proper emission, leakage, and short circuits. Use Tube Tester I–177, I–177–A, or I–177–B or place doubtful tubes in a unit known to be operating normally.

b. INSPECTING, CLEANING, AND TESTING FUSE.

(1) *Inspecting.* Inspect fuse ends for evidence of burning, corrosion, and looseness.

(2) *Cleaning.* Clean fuse ends with emery cloth and then wipe with a clean cloth. If a file is used to remove deep pits, use crocus cloth to leave a smooth contact surface and, then wipe dry with a clean cloth.

(3) *Testing.* Check fuse for continuity.

c. INSPECTING PILOT LAMP. Inspect the lamp for continuity of filament. Make sure that the lamp base is not loose.

31. Cleaning and Inspecting Chassis Assembly

a. CLEANING. Through cleaning of the CI meter is necessary to insure optimum performance by preventing corrosion, rust, and dust from damaging parts or causing arc-over or low-resistance leakage between high-voltage points and ground. Remove loose dust and

dirt with a brush or blower. Use a brush or cloth moistened with solvent (SD) to remove dirt and grease which adheres to the chassis (fig. 12) and parts.

b. Inspecting. After a meter has been cleaned thoroughly and carefully, make a visual inspection of parts and wiring for rust, corrosion, loose connections, frayed and burned insulation, loose screws, and burned and charred resistors and coils. Carefully inspect tube sockets for broken contacts and broken insulation, and terminal boards for broken lugs and signs of burning. Inspect and tighten all loose set screws.

32. Reassembling Crystal Impedance Meter

Replace the tubes, fuses, and pilot lamp in the CI meter. Be sure the tubes are replaced in the correct sockets (fig. 11). Refer to paragraph 38 for replacement procedures.

Section III. TROUBLE SHOOTING

33. Trouble-Shooting Procedure

a. Data. Take advantage of the material supplied in this manual. It will help in the rapid location of faults. Refer to the following trouble-shooting data:

Fig. or par. No.	Description
Par. 36*b*	Trouble location chart.
Par. 36*c*	Resistance chart.
Fig. 12	Chassis assembly, bottom view.
Fig. 13	Socket voltage and resistance diagram.
Fig. 16	Capacitor color codes.
Fig. 17	Resistor color codes.
Fig. 18	Wiring diagram.
Fig. 19	Complete over-all schematic diagram.

b. Step-By-Step Procedure.

(1) Check the trouble report to determine the probable cause of trouble. When checking the report, refer to the complete over-all schematic diagram (fig. 19) to localize the fault to a particular part.

(2) Inspect the equipment for damaged or broken wiring, loose screws, burned resistors, and charred wiring. If the fault cannot be located by this method, trace the circuit by making continuity measurements.

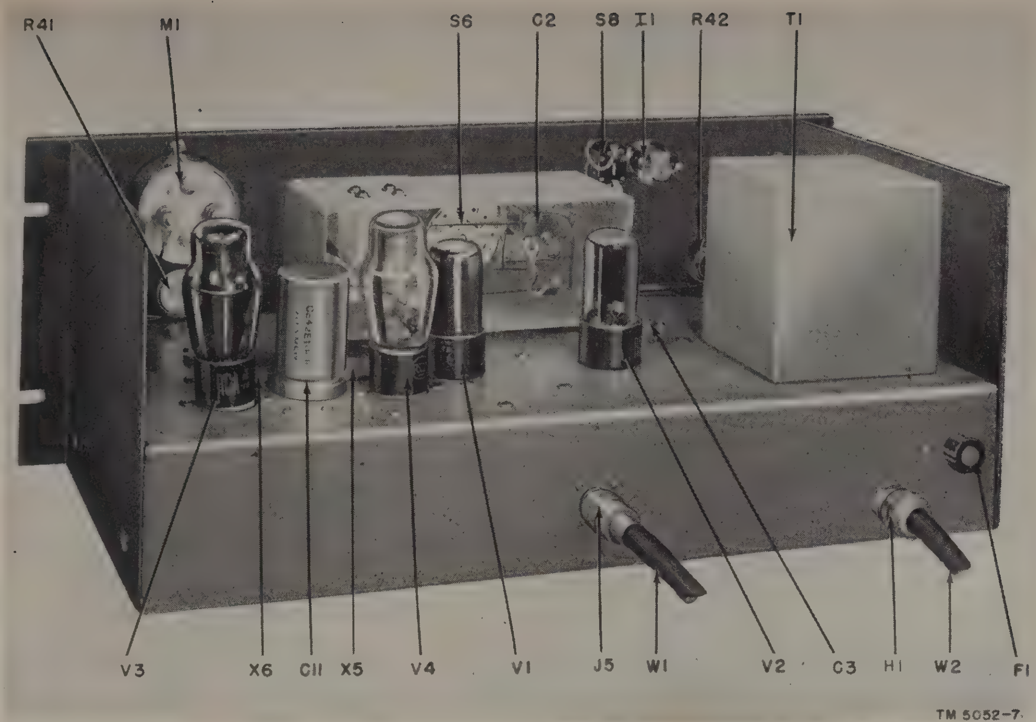


Figure 11. Panel and chassis asssembly, rear view.

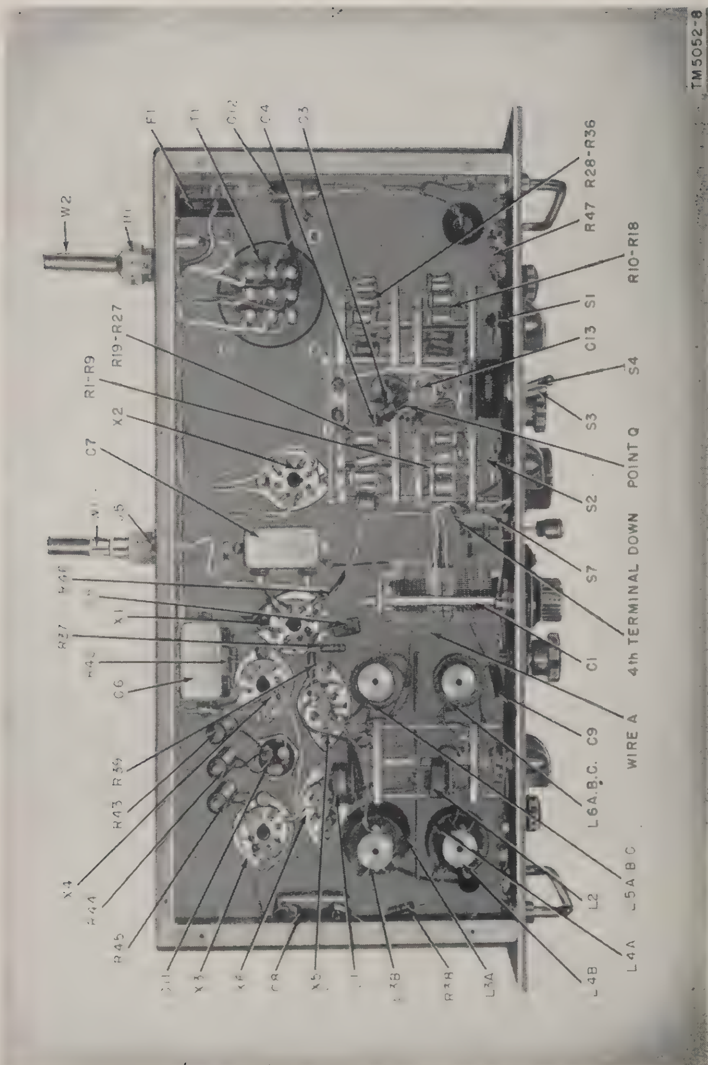


Figure 12. Chassis assembly, bottom view.

(3) When locating the fault by elimination, start at a point where the circuit is known to have continuity; proceed step by step until the fault is located.

(4) Check for short circuits, open circuits, or lack of proper voltage. Study the equipment performance checklist (par 15).

34. Equipment Required

The following equipment is needed for trouble shooting:

a. Common hand tools.

b. Electronic Multimeter TS–505/U.

c. Multimeter TS–352/U.

35. General Precautions

Whenever the CI meter is serviced, observe the following precautions very carefully because careless replacement of parts often causes new faults.

a. Before a part is unsoldered, note the position of the leads. If the part, such as a transformer, has a number of connections, tag each of the leads before disconnecting.

b. Be careful not to damage other leads when pulling or pushing them out of the way. The oscillator circuit is very critical to lead position. Leads must be replaced in the same position, $\pm\ ^{1}/_{16}$ inch.

c. Do not allow drops of solder to fall into the equipment; they may cause short circuits.

d. Make well-soldered joints. A carelessly soldered connection may create a new fault.

e. Replace components in the oscillator circuits in their original positions. A part which has the same electrical value but a different physical size may cause trouble in the r-f oscillator circuit. The leads must be kept the same lengths as the original wiring.

36. Trouble-Shooting Charts

a. Preliminary Procedure. When trouble occurs in the equipment, proceed as follows:

(1) Provide for favorable working conditions.

(2) Read this technical manual and study the schematic diagram (fig. 19).

(3) Make simple, direct, preliminary tests.

(*a*) Feel the tubes for filament heat.

(*b*) Check power sources and fuses.

(*c*) Check method of operation and performance.

(*d*) Proceed according to *b* below.

b. Trouble Location Chart. This chart lists the symptoms which the repairman can observe, either visually or audibly, while making a few simple tests, determining the possible causes, and accomplishing the remedial action.

Symptom	Possible trouble	Remedial action
1. Pilot lamp does not light.	1. Cord not plugged into source or open.	1. Check at source and at unit (terminals 1 and 2 on T1) (figs. 12 and and 13).
	Fuse blown out.	Check and replace.
	Transformer T1 open.	Check and replace.
	Pilot lamp burned out.	Check and replace.
2. Voltage regulator tubes do not light.	2. Rectifier tube V2 is faulty.	2. Replace tube V2.
	High voltage winding of transformer T1 is open.	Check and replace transformer T1.
3. No apparent reading or deflection of the GRID CURRENT meter.	3. Oscillator tube V1 not oscillating.	3. Check and replace tube.
	Crystal current too high.	Check operational procedure, increase the GRID CURRENT control to maximum sensitivity, and decrease the CRYSTAL CURRENT control.
	Wiring shorted.	Check continuity.
	Meter open.	Check and replace meter.
	Transformer open.	Measure a-c and d-c voltages shown in figure 13.
	R-f coil open.	Measure a-c and r-f voltages shown in figure 13.
	CRYSTAL CURRENT potentiometer R42 open.	Check voltage on pin No. 4 of tube V1 as control is varied. Replace control if faulty.
	Oscillator coil open.	Check all ranges on the CALIBRATE position. Replace faulty coil.
4. Oscillation without crystal in socket (par. 45).	4. Wiring disturbed.	4. Move wire A (fig. 12) until oscillation stops.

c. Resistance Chart. The d-c resistances of T1 and V1 should correspond with those listed below. The resistances indicated for V1 are measured between the pins indicated and ground. Refer to figure 13 for the socket voltages and resistances of T1, V1, V2, V3, and V4.

Transformer or tube	Terminals or pins	Resistance (ohms)
T1	1–2	11.5
	3–4	320
	4–5	320
	6–7	Less than 1
	8–9	Less than 1
V1	1	0
	2	INF
	3	INF
	4	25,000
	5	22,000
	7	INF
	8	270

37. Localizing Trouble

Be sure to place the controls in the positions indicated in figure 13. Check the d-c and filament voltages on the socket pins of tube V1 (fig. 13). Correct d-c and filament voltages indicate the proper operation of the power supply. Measure the r-f voltages on the socket pins of tube V1 (fig. 13). Correct r-f voltages indicate operation of the tuned circuits and tube V1. If voltages appear correct, refer to the wiring diagram (fig. 18) and check the crystal socket network and the decade resistor assembly for wiring continuity or shorts to chassis.

38. Replacement Procedures

a. General. When failure of a component of the equipment makes replacement necessary, use the disassembly procedures given in *b* below. As the first step in this replacement procedure, remove the cover and bottom plate by removing the No. 6–32 screws on the sides and back and in the four corners and rear edge of the bottom plate.

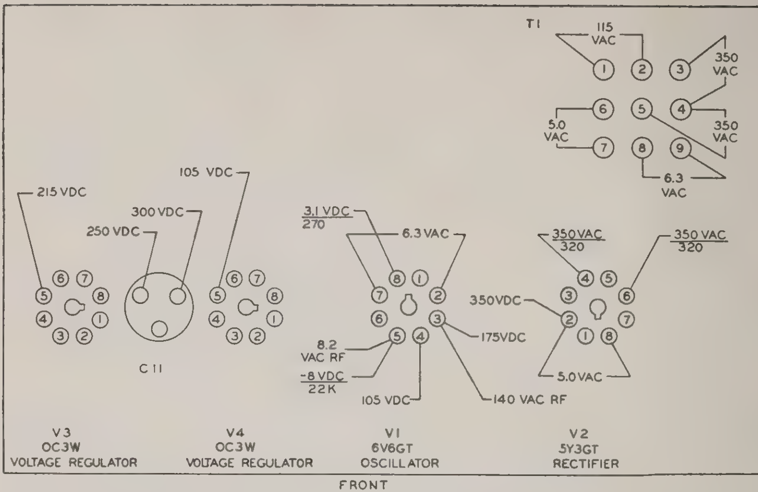
b. Disassembly. To disassemble or strip the equipment completely proceed as follows:

(1) Remove all knobs and dials from the front panel (fig. 3) by loosening the setscrews.

(2) Carefully remove meter M1. Be sure to remove the wire lugs from the studs before removing the three No. 6–32 screws that hold the meter to the panel.

(3) Remove the three No. 4–40 screws that fasten the crystal socket assembly to the front panel.

(4) Unsolder the two connecting wires (tag points) on the under side of the chasses (fig. 12).



NOTE: Place controls in positions shown below before making measurements.

CONTROL	POSITION	CONTROL	POSITION
CALIBRATE CRYSTAL .	CALIBRATE	S-A..................	S
X10 - X1000...........	0	GRID CURRENT.......	Full counterclockwise
X100 - X10000.........	0	KILOCYCLES..........	75 - 120
CRYSTAL CURRENT...	Full clockwise	TUNING..............	50

NOTES:
1. ALL VOLTAGES TO CHASSIS UNLESS OTHERWISE INDICATED.
2. RESISTANCE VALUES MEASURED WITH POWER OFF EQUIPMENT.
3. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS.

TM 5052-9

Figure 13. Socket voltage and resistance diagram.

(5) Remove the crystal socket assembly.

(6) Tag and unsolder the wires from toggle switch S8, pilot lamp E1, and potentiometers R41 and R42 (fig. 11). Remove these components from the panel.

(7) Unsolder the wires and remove switch S3 (X10–X1000).

(8) Unsolder the wires and remove lever switch S7 (CALIBRATE—CRYSTAL).

(9) The chassis now has been disassembled to the point that various other switches, coils, resistor decades, etc., can be removed as desired without interference. The self-supporting resistors and fixed capacitors are unsoldered for removal.

c. Reassembly. To reassemble the equipment, reverse the above procedures. Mount the crystal socket assembly after the oscillator coils and the tuning capacitor C1 are in place, because this box covers the mounting screws of components on the under side of the chassis.

Section IV. FINAL TESTING AND CALIBRATION

39. Test Equipment Required for Final Testing and Calibration

The test equipments required for final testing and calibration are listed below with their respective stock numbers and technical manuals, where available.

Test equipment	Signal Corps stock No.	Technical manual
Q-Meter (Boonton type 160-A)	3F3381	TM 11-2635
Frequency Meter Set SCR-211-A, B, C, D, E, F, J, K, L, M, N, O, P, Q, R, T, AA, AC, AE, AF, AG, AH, AJ, AK, AL, and AN.	2C1411	TM 11-300
Electronic Multimeter TS-505/U	3F4325-505	Manufacturer's Instruction Book
Multimeter TS-352/U	3F4325-352	TM 11-5527
RF Bridge Type 916-A (Navy type—60094)	3F2009	TM 11-2633
Test Set I-49	3F4049	TM 11-2019
Signal Generator TS-497A/URR	3F4325-497	TM 11-5030
Precision Capacitor Type 722-D, General Radio Co., or equivalent.	3F2470	

40. Readjustment of Capacitor C3

Make this adjustment only if the resistance decades or the crystal socket assembly have been replaced. The capacity from point P (figs. 3 and 19) to ground (with the CALIBRATE—CRYSTAL switch S7 in the CALIBRATE position) must equal that of point Q (figs. 12 and 19) to ground (with switch S7 in the CRYSTAL position). Capacitor C3 is varied until these two capacities are equal. These capacities are measured by use of Q Meter TS-617A/U and precision capacitor type 722-D, General Radio Co., or equivalent (fig. 14). A crystal-controlled, 400-kc oscillator (frequency generator) is used to stabilize the frequency of the Q meter; a standard inductance coil is used to tune the Q meter to resonance. Connect these units together as shown in figure 14 with No. 12 AWG solid copper wire supported on 2-inch centers.

a. MEASUREMENT OF CAPACITY FROM POINT P TO GROUND. Place the CALIBRATE—CRYSTAL lever switch S7 in the CALIBRATE position and proceed as follows:

(1) Connect a wire from one of the rivets holding the polystyrene crystal socket to the HIGH terminal of the precision capacitor (fig. 14). This wire should be stiff, bare, located as far as possible from anything grounded, and not larger than No. 16 AWG bare copper tinned wire. The same physical relationship should exist for every measurement

with the wire connection as short as possible and kept away from ground. Arch the wire about 3 inches away from ground as soon as it leaves the terminal.

(2) Connect a stiff No. 16 AWG wire from the most convenient point of the panel or chassis of the equipment being measured to the ground terminal of the precision capacitor. It is more important to keep the wires in the same physical relationship with each other and to ground, when the capacity measurement is made, than to shorten the wires.

(3) Connect the ground terminal on the precision capacitor to a good ground such as a water pipe, a steam pipe, or a BX electric cable if it is well grounded. Errors due to capacity between the equipment being tested and your own body will thus be eliminated.

(4) Disconnect the wire to the HIGH terminal, but allow the wire to remain near the terminal. Set the precision capacitor to 200 $\mu\mu$f and tune the Q meter to resonance by using a standard induction coil (fig. 14). Reconnect the wire to the HIGH terminal and rotate the precision capacitor dial until resonance is reached again. The capacitance value of P to ground is the difference in reading between 200 $\mu\mu$f and the new setting of the precision capacitor dial.

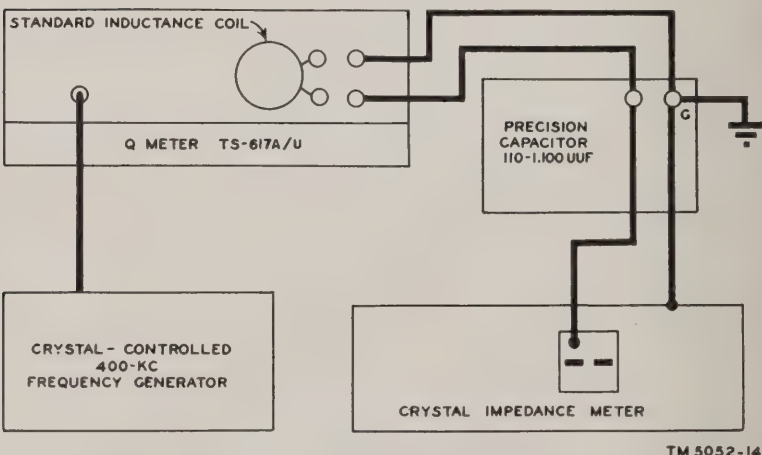


Figure 14. Test circuit for measurement of points P and Q to ground.

b. Measurement of Capacity From Point Q to Ground.

(1) Place the CALIBRATE—CRYSTAL lever switch S7 in the CRYSTAL position and proceed as described in *a* above, except that the wire connected to the HIGH terminal of

the precision capacitor must be moved from point P to point Q (figs. 12 and 19). To make this connection, solder a short length of wire to point Q, remove the button in the bottom plate of the CI meter, and bring the wire through the hole.

(2) Adjust variable capacitor C3 with a nonmetallic screw driver, or other means, through a ¼-inch diameter hole in the bottom plate, until the measured capacity is equal to the capacity measured from P to ground (*a*(4) above).

41. Measurement and Adjustment of Frequency

Note. These adjustments have been made during manufacture. Do not repeat these adjustments unless an oscillator coil has been changed. The overlap of the frequency ranges should be approximately as tabulated below. Measure the frequency of oscillation with Frequency Meter Set SCR–211 connected to r-f cable assembly W1 (fig. 11). The frequency overlap can be adjusted only by adding or removing turns from the tuned plate or grid inductances.

a. Connect the CI meter to the frequency meter with cable assembly W1.

b. Place a composition resistor, with value listed in the second column of the table below, into the crystal socket.

c. Place switch S6 in the S position, S7 in the CRYSTAL position, S8 to the ON position, and switches S5 and I3 to the positions indicated. Set the GRID CURRENT control R41 to maximum; increase the CRYSTAL CURRENT control until a convenient reading of grid current is obtained. Read the frequency meter.

d. The frequency adjustment table follows:

Kilocycle switch (S5) position (kc)	Crystal socket resistance (ohms)	Tuning dial (I–3) position	
		Frequency at 0 position (kc)	Frequency at 100 position (kc)
75–120	15 K	71.6	121
120–190	15 K	117	204
190–290	15 K	175	315
290–465	15 K	270	475
465–680	9 K	456	708
680–1100	5 K	674	1,320

42. Frequency Correlation between CRYSTAL and CALIBRATE Positions

Check frequency correlation between the CRYSTAL and CALIBRATE positions (fig. 3) as follows:

a. Under operating conditions, switch S5 to range 680–1100 kc.

b. Set the decade resistors to 250 ohms.

c. Switch to the CALIBRATE position.

d. Set R41 (GRID CURRENT meter sensitivity) control to maximum. Increase the CRYSTAL CURRENT control R42 until a meter reading of 150 μa is obtained.

e. Adjust the TUNING capacitor dial to obtain 1 mc. Measure this frequency with Radio Receiver BC–348–M; Radio Receiver BC–342 may be used if the latter is not available. Zero beat the signal with the bfo of the receiver. After obtaining 1 mc, readjust the CRYSTAL CURRENT control to give a meter reading of approximately 150 μa.

f. Switch to the CRYSTAL position.

g. Turn shorting switch S6 to the S position.

h. Insert a 250-ohm, ½-watt composition resistor into the crystal socket.

i. Note the audio-output frequency of the receiver. The difference in frequency caused by moving S7 from CRYSTAL to CALIBRATE should be less than 1,000 cycles.

43. Performance Test

Test the performance of the CI meter for each position of band switch S5 (KILOCYCLES) as follows:

a. With the CALIBRATE—CRYSTAL switch S7 in the CALIBRATE position, measure the capacity from point P to ground with Q Meter TS–617A U in conjunction with precision capacitor, type 722-D, General Radio Co., or equivalent, as described in paragraph 40.

b. Place the CALIBRATE—CRYSTAL switch S7 in the CRYSTAL position and vary C3 until the measured capacity from point Q to ground is equal to that obtained when measuring from point P to ground. (It is not necessary to repeat the procedure of *a* and *b* for successive band switch positions.)

c. Place the CALIBRATE CRYSTAL lever switch S7 in the CALIBRATE position.

d. Set the decade resistors successively to the values listed in the table (*n* below) for the band being tested.

e. Adjust the TUNING dial to obtain the corresponding frequency listed.

f. Rotate the GRID CURRENT METER adjust control (E4) in a clockwise direction until all the resistance is in the meter shunt circuit.

g. Adjust the CRYSTAL CURRENT control R42 until 150 μa of rectified GRID CURRENT indication is obtained.

h. Place the CALIBRATE—CRYSTAL lever switch in the CRYSTAL position.

i. Turn the load capacity shorting switch S6 to the S position (fig. 3).

j. Insert the same value of resistance as described in *d* above into the crystal socket. This resistance must be of the composition type with leads as short as possible. The r-f resistance should be within ±1 percent of the desired value as measured on RF Bridge Type 916–A (Navy type—60094).

k. The GRID CURRENT meter indication must not vary more than ±3 percent or 4.5 μa from the 150-μa point.

l. If the variation is greater than ±3 percent, adjust C13 as follows:

(1) Insert a 5,000-ohm carbon resistor in the crystal socket.
(2) Turn S6 to the S position.
(3) Adjust resistor decades to 5,000 ohms.
(4) Turn S5 to the highest frequency band (band 6).
(5) Adjust TUNING dial I-3 to 50 divisions.
(6) Adjust capacitor C13 so that equal grid currents are obtained in both the CRYSTAL and CALIBRATE positions.

m. If the variation is still greater than ±3 percent, repeat the tests and adjustments described in paragraphs 40, 41, and 42.

n. The table of resistance values for frequency settings follows:

Range (kc)	Resistance value (ohms)	Frequency (kc)
75–120	15 K	100
120–190	15 K	140
190–290	15 K	225
290–465	15 K	350
465–680	9 K	520
680–1100	5 K	800

44. Checking Load Capacitance Chart

The load capacitance chart is prepared from data obtained by measuring the actual capacitance value (within ±.1 $\mu\mu$f) of capacitor C2 (LOAD CAPACITY, figs. 3 and 11) in the circuit with shorting switch S6 in the A position. Plotting points are taken at every dial division from 0 to 12, at every two divisions from 12 to 30, and at every five divisions from 30 to 100 on the dial. Connections are made as shown in figure 15. The frequency stability of Q Meter TS–617A/U must be very good. Accomplish this by controlling the Q meter with a crystal-controlled, 400-kc oscillator. The wiring between units must be No. 12 AWG solid copper wire supported on 2-inch centers. The Q meter is tuned to resonance by using a standard inductance with the precision capacitor set at 200 $\mu\mu$f and the LOAD CAPACITY dial set at 0. The LOAD CAPACITY dial then is moved up one

division from 0 to 12 on the dial, two divisions from 12 to 30, and five divisions from 30 to 100; the Q meter is retuned to resonance with the precision capacitor. The difference in the reading of the precision capacitor is the value of capacitance added by moving C2. Record this value and proceed with the reading of the next point. Plot the data as shown in figure 4 and check these curves against those on the load capacitance chart supplied with each equipment (par. 13).

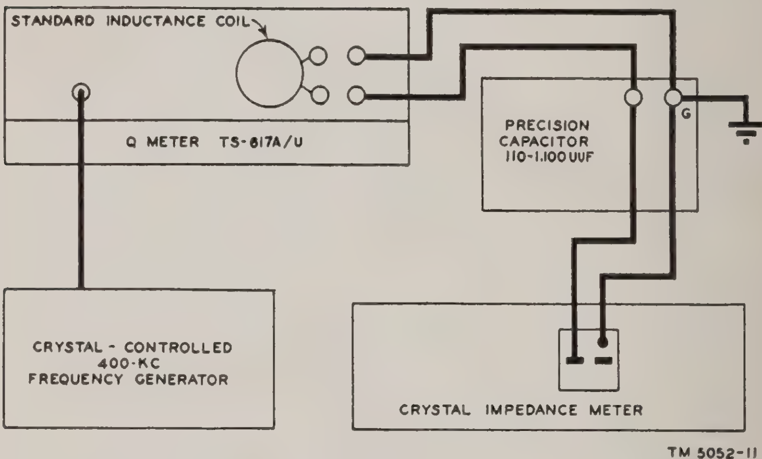


Figure 15. Test circuit for calibration of LOAD CAPACITY dial.

45. Oscillation Test

With CALIBRATE—CRYSTAL switch S7 in the CRYSTAL position (no crystal in socket), rotate TUNING knob I–3 (which controls capacitor C1) through 180° for each band switch position with R41 and R42 advanced in their extreme clockwise direction. No self-controlled oscillation should be observed either by an indication of grid current other than residual grid current or by the presence of a signal on a communication receiver. The condition of oscillation can be eliminated by proper placement of grid and plate circuit wiring. In the replacement of parts and repairs, these wires may have been disarranged. The position of wire A (figs. 12 and 18) is very critical and *must be replaced within 1/16 of an inch;* a small movement of this wire will put the equipment into a condition of oscillation.

CHAPTER 6
SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

46. Packaging Crystal Impedance Meter TS–537/TSM

a. Cushion the set on all surfaces with cells or pads fabricated of corrugated fiberboard.

b. Obtain the proper amount of desiccant, as prescribed in table II, section E of Joint Army-Navy Specification JAN–P–116, and place the cushioned set, together with technical manuals and desiccant, within a close-fitting, regular-slotted style corrugated fiberboard box.

c. Seal the entire closure with gummed Kraft tape and blunt all corners of the box.

d. Place the boxed set within a moisture-vaporproofed barrier, type I, and heat-seal the closure.

e. Place the moisture-vaporproofed set within a second close-fitting, regular-slotted style corrugated fiberboard box, and seal the entire closure with water-resistant tape or adhesive.

f. Overwrap the boxed set in waterproof barrier material, type L–2 or M.

g. Completely seal all joints, seams, and closures with adhesive or other suitable seal equivalent in moisture resistance to that of the body material, in accordance with approved specifications.

47. Packing and Marking

Materials used in packing, as described in *a* and *b* below, should comply with the requirements of Joint Army-Navy Specification JAN–P–100.

a. Place the equipment, packaged as described in paragraph 46, within a nailed wooden box lined inside with a 2-inch thickness of excelsior compacted to 3 pounds per cubic foot. The shipping container should *not* be lined with a waterproof bag.

b. For oversea shipment only, the shipping container should be strapped in accordance with approved techniques.

Section II. DEMOLITION TO PREVENT ENEMY USE

48. Methods of Demolition

a. SMASH. Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

b. CUT. Use axes, handaxes, machetes.

c. BURN. Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

d. EXPLODE. Use firearms, grenades, TNT.

e. DISPOSE. Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

f. Other. Use anything immediately available for destruction of this equipment.

49. Destruction of Components

When ordered by your commander, destroy all equipment to prevent its being used or salvaged by the enemy.

a. Smash (par. 48*a*) the cabinet, controls, coils, switches, capacitors, transformers, etc.

b. Cut (par. 48*b*) cords and wires.

c. Burn (par. 48*c*) cords, capacitors, coils, resistors, wiring, load capacitance chart, and technical manual.

d. Bend the panels and chassis.

e. Bury or scatter (par. 48*e*) all remaining parts of the equipment.

f. Destroy everything.

APPENDIX I

REFERENCES

Note. For availability of items listed, check SR 310-20-3 for field manuals and JANAP'S. Check SR 310-20-4 for technical manuals, technical bulletins, and supply bulletins.

1. Army Regulations

AR 380-5	Safeguarding Military Information.

2. Supply Publication

SB 11-76	Signal Corps Kit and Materials for Moisture- and Fungi-Resistant Treatment.

3. Technical Manuals on Auxiliary Equipment and Test Equipment

TM 11-5527	Multimeter TS-352/U.
AN-16-40BC224-3 (Air Force)	Radio Receiver BC-348-M.
TM 11-300	Frequency Meter Sets SCR-211-A, B, C, D, E, F, J, K, L, M, N, O, P, Q, R, T, AA, AC, AE, AF, AG, AH, AJ, AK, AL, and AN.
TM 11-472	Repair and Calibration of Electrical Measuring Instruments.
TM 11-850	Radio Receivers BC-312-A, -C, -D, -E, -F, -G, -J, -L, -M, -N, -HX, and -NX, BC-342-A, -C, -D, -F, -J, -L, -M, and -N, BC-314-C, -D, -E, -F, and -G, and BC-344, and -D.
TM 11-2019	Test Set I-49.
TM 11-2530	Frequency Standard TS-308/U.
TM 11-2540	Quartz Crystals—Theory, Fabrication, and Performance Measurements.
TM 11-2606	Test Set AN/FSM-3, Tool Equipment TK-40/FSM-3, and Maintenance Kit MK-40/FSM-3 (Formerly Depot Crystal Equipment AN/FSM-1).

TM 11–2627	Tube Testers I–177, and I–177–A.
TM 11–2633	RF Bridge, Type 916-A (Navy type—60094).
TM 11–2635	Q Meter Boonton Type 160–A.
TM 11–4001	Repair Instructions for Radio Receivers BC–312, –A, –C, –D, –E, –F, –G, –J, –L, –M, –N, –HX, and –NX, BC–342–A, –C, –D, –F, –J, –L, –M, and –N.
TM 11–5030	Signal Generator TS–497A/URR.
TM 11–5051	Crystal Impedance Meter TS–330/TSM.
	Manufacturer's Instruction Book, Electronic Multimeter TS–505/U.

4. Painting, Preserving and Lubrication

TB SIG 13	Moistureproofing and Fungiproofing Signal Corps Equipment.
TB SIG 66	Winter Maintenance of Signal Equipment.
TB SIG 72	Tropical Maintenance of Ground Signal Equipment.
TB SIG 75	Desert Maintenance of Ground Signal Equipment.

5. Decontamination

TM 3–220	Decontamination.

6. Demolition

FM 5–25	Explosives and Demolitions.

7. Military (JAN) Specifications

a. Packaging Specifications.

JAN–D–169	Desiccants (activated).

b. Packaging and Packing for Oversea Shipment.

JAN–P–100	General specification.
JAN–P–106A	Boxes; wood, nailed.
JAN–P–116	Preservation, methods of.
JAN–P–125	Barrier-materials, waterproof, flexible.
JAN–P–131	Barrier-material; moisture-vaporproof, flexible.

c. U. S. Army Specifications.

100–2E	Marking Shipments by Contractors, standard specification for (and Signal Corps Supplement thereto).

d. SIGNAL CORPS INSTRUCTIONS.

720–7	Standard Pack.
726–15	Marking of Interior Containers (for Signal Corps Equipment).

8. Other Publications

MIL–C–3098	Crystal Units, Quartz.
MIL–C–10405 (Sig C)	Crystal Units, Quartz, Pressure and Spacer Mounted.
SR 310–20–3	Index of Training Publications (Field Manuals, Training Circulars, Firing Tables and Charts, Army Training Programs, Mobilization Training Programs, Graphic Training Aids, Joint Army-Navy Air Force Publications, and Combined Communications Board Publications).
SR 310–20–4	Index of Technical Manuals, Technical Regulations, Technical Bulletins, Supply Bulletins, Lubrication Orders, Modification Work Orders, Tables of Organization and Equipment, Reduction Tables, Tables of Allowances, Tables of Organization, and Tables of Equipment.
SR 700–45–5	General—Unsatisfactory Equipment Report (Reports Control Symbol CSGLD-247).
SR 745–45–5 NAV DEPT SERIAL 85POO AFR 71–4	Report of Damaged or Improper Shipment (Reports Control Symbols CSGLD–66 (Army), SandA–70–6 (Navy) and AF–MC–U2 (Air Force)).
TB SIG 123	Preventive Maintenance Practices for Ground Signal Equipment.
TB SIG 178	Preventive Maintenance Guide for Radio Communication Equipment.
TM 11–453	Shop Work.
TM 11–455	Radio Fundamentals.
TM 11–660	Introduction to Electronics.
TM 11–4000	Trouble Shooting and Repair of Radio Equipment.
TM 38–650	Basic Maintenance Manual.

APPENDIX II

IDENTIFICATION TABLE OF PARTS

Note. The fact that a part is listed in this table is not sufficient basis for requisitioning the item. Requisitions must cite an authorized basis, such as the specific T/O&E, TA, SIG 6, SIG 7&8, SIG 7-8 10, SIG 10, list of allowances of expendable material, or other authorized supply basis. For an index of available supply catalogs in the Signal portion of the Department of the Army Supply Catalog, see the latest issue of SIG 1, Introduction and Index.

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
	CRYSTAL IMPEDANCE METER TS-537/TSM: 19″ lg x 10½″ wd x 7″ h o/a; freq continuously varied from 75 kc to 1100 kc in 6 ranges w/provision for plug-in coils for freq below 75 kc, decade resistors from 0–990 ohms in 10-ohm steps, 0-9900 ohms in 100-ohm steps, and 0–99,000 ohms in 1,000-ohm steps, decade resistor range selection by means of toggle sw; operates from 115 v ac, 50–1720 cyc line; metal case, black wrinkle finish; incl r-f pickup cable assembly, calibration chart, and two technical manuals; designed for rack mtg; p/o Army-Navy Crystal Test Set AN/TSM-3.	L-f crystal impedance meter; measures series-resonant and anti-resonant resistances of piezoelectric crystals.	3F4325-537
W2	CABLE ASSEMBLY, power: Cord CX-112/U; two No. 16 AWG cond; 6 ft lg excluding terminations.	Connects CI meter to 115-volt ac, 1,720 - cycle power sources.	3E6000-112
W1	CABLE ASSEMBLY, R-F: uses Radio Frequency Cable RG-8A/U; 4 ft lg excluding terminations.	Provides connection to external frequency meter.	3E7350-2.58.2
C4	CAPACITOR, fixed: mica dielectric; 30 $\mu\mu$f ±5%; 500 vdcw; JAN type # CM-20C300J.	Compensates for capacity between the crystal socket assembly and chassis	3K2030032
C5	CAPACITOR, fixed: mica dielectric; 100 $\mu\mu$f ±5%; 500 vdcw; JAN type # CM-20C101J.	Blocks the rectified control grid current of V1 from flowing into r-f coils L1, L3A, L3B, L5A, L5B, and L5C.	3K2010132
C6, C7, C8	CAPACITOR, fixed: paper dielectric; 250,000 $\mu\mu$f ±10%; 600 vdcw; JAN type # CP53B1EF254K.	C6 — Bypasses rf from cathode of V1 to ground. C7—Bypasses rf from screen of V1 to ground. C8—Blocks rf from the power supply.	3DA250-362

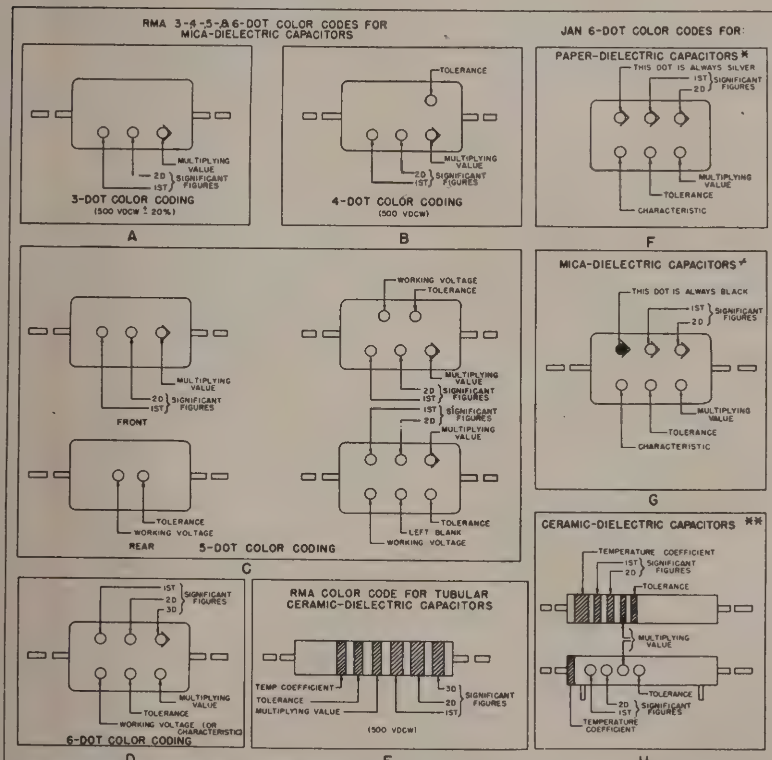
Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
C9	CAPACITOR, fixed: mica dielectric; 10,000 $\mu\mu f$ $\pm 10\%$; 300 vdcw; JAN type # CM35C103K.	Couples plate circuit of V1 to crystal-calibrate circuit.	3K3510331
C11	CAPACITOR, fixed: electrolytic; 2 sect.; 10 μf ea sect.; 450 vdcw ea sect.; JAN type # CE42F100R.	Filters output of power supply rectifier.	3DB10-168
C12	CAPACITOR, fixed: paper dielectric; 3000 $\mu\mu f$ $\pm 20\%$; 600 vdcw; JAN type # CP28A1EF302M.	Line filter: bypasses r-f from the input power line to ground.	3DA3-133
C1	CAPACITOR, variable: air dielectric; plate meshing type, # two sect.; 8 to 150 $\mu\mu f$ per sect.	Tunes the grid and plate coils of V1.	3D9150V-36
C2	CAPACITOR, variable: air dielectric; plate meshing type, # single sect.; 4.5 to 102 $\mu\mu f$.	Adds series capacitance to crystal circuit for anti-resonance tests.	3DK9100V-31
C3	CAPACITOR, variable: air dielectric; single sect., plate meshing type; 5 to 42 $\mu\mu f$; JAN type # CT1CD40.	Adjusts the capacity between the decade resistors and ground to equal the capacity of the crystal socket assembly to ground.	3D9042V-7
C13	CAPACITOR, variable: ceramic; 1.5 to 7 $\mu\mu f$; JAN type # CV11A070.	Compensates for the effect of stray wiring capacities.	3D9007V-17
N104	CHART, calibration: serial number corresponds to that on associated CI meter; black lines and printing, green chart lines.	Translates the dial markings of the LOAD CAPACITY dial into $\mu\mu f$.	
L3, L4	COIL ASSEMBLY, R-F: two coils, 10.9 and 5.4 mh for ranges of 120–190 kc and 190–290 kc, respectively.	L3—Grid oscillator coils for ranges between 120 and 290 kc. L4—Plate oscillator coils for ranges between 120 and 290 kc.	3C4052A-3
L5, L6	COIL ASSEMBLY, RF: three coils, 2.2 mh, .93 mh, and .41 mh for ranges of 290–465 kc, 465–680 kc, and 680–1110 kc, respectively.	L5—Grid oscillator coils for ranges between 290 and 1,100 kc. L6—Plate oscillator coils for ranges between 290 and 1,100 kc.	3C4052A-2
L1, L2	COIL, RF: choke; unshielded; 30 mh; for 75-120 kc range.	L1 — Grid oscillator coil for 75- to 120-kc range. L2—Plate oscillator coil for 75- to 120-kc range.	3C368-21
P1	CONNECTOR, plug: 2 flat parallel blades; straight; 10 amp, 250 v.	Line plug for standard 115-volt receptacle.	6Z7565.3
P2	CONNECTOR, plug: single round male cont; JAN type # PL-259.	Connects W1 to J5.......	2Z7226-259

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
J1, J2, J3, J4	CONNECTOR, receptacle: single round female cont; straight.	Provide for measurement of voltage across the crystal under test. Provide for connection of test lead to chassis.	2Z5594.5
J5	CONNECTOR, receptacle: Socket SO 239; single round female cont; straight.	Connects r-f cable assembly W1 to CI meter.	2Z8799-239
I-2	DIAL: brass dial with bakelite knob; marked 0 to 100 over 180° arc; incl friction drive and vernier.	LOAD CAPACITY dial; varies C2.	2Z3723-167
I-3	DIAL: brass dial with bakelite knob; marked 0 to 100 over 180° arc; incl friction drive.	TUNING capacitor dial; varies C1.	2Z3723-168
H1	FITTING, conduit: straight compression type for connecting cable to box; threaded connection to box, compression connection to cable.	Clamps power cable assembly W2 to chassis.	6Z4847-3
F1	FUSE FU-26: cartridge; 1 amp, 250 v; ferrule term.	Line fuse; protects the CI meter from current overload.	3Z1926
E3	FUSEHOLDER: extractor post type; for single 3AG cartridge fuse; 15 amp, 250 v.	Holds a-c line fuse F1.....	3Z3275
E6	INSULATOR, stand-off: cylindrical; white glazed porcelain; ¾″ lg; ⅜″ OD; JAN type # NP2W0106.	Stand-off insulator in crystal socket assembly.	3G3601-06
E4, E5	KNOB: round black bakelite; for ¼″ dia shaft; engraved arrow; push-on type.	E4—Knob for GRID CURRENT control; varies R41. E5—Knob for CRYSTAL CURRENT control; varies R42.	2Z5822-385
E7, E8, E9, E10	KNOB: bar; black bakelite; for ¼″ dia shaft; engraved arrow; push-on type.	Knobs for switches S1, S3, S5, and S6.	2Z5838
E1	LAMP LM-27: 6-8 v, .25 amp; miniature bayonet base.	Pilot lamp; indicates the presence of line voltage.	2Z5927
I-1	LIGHT, indicator: w/red lens; miniature bayonet base; bulb T-3¼.	Lamp assembly for lamp E1.	2Z5991
M1	METER, ammeter: dc; 0-200 μa; JAN type MR26W200DCUA.	Indicates the magnitude of oscillation of V1 by measuring its grid current.	3F872-31
H3	NUT, lock: speed nut type; ⅝″-8 thread.	Locknut for fitting H1....	6L3680-8.3
R1	RESISTOR, fixed: comp; 10 ohms ±1%; ½ w; tinned copper leads.	Calibration resistor; part of decade resistor.	3Z6001-143
R2	RESISTOR, fixed: comp; 20 ohms ±1%; ½ w.	Same as R1..............	3Z6002-80
R3	RESISTOR, fixed: comp; 30 ohms ±1%; ½ w.	Same as R1..............	3Z6003-75
R4	RESISTOR, fixed: comp; 40 ohms ±1%; ½ w.	Same as R1..............	3Z6004-56

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
R5	RESISTOR, fixed: comp; 50 ohms ±1%; ½ w.	Same as R1	3Z6005–193
R6	RESISTOR, fixed: comp; 60 ohms ±1%; ½ w.	Same as R1	3Z6006–47
R7	RESISTOR, fixed: comp; 70 ohms ±1%; ½ w.	Same as R1	3Z6007–21
R8	RESISTOR, fixed: comp; 80 ohms ±1%; ½ w.	Same as R1	3Z6008–25
R9	RESISTOR, fixed: comp; 90 ohms ±1%; ½ w.	Same as R1	3Z6009–11
R10	RESISTOR, fixed: comp; 100 ohms ±1%; ½ w.	Same as R1	3Z6010–238
R11	RESISTOR, fixed: comp; 200 ohms ±1%; ½ w.	Same as R1	3Z6020–267
R12	RESISTOR, fixed: comp; 300 ohms ±1%; ½ w.	Same as R1	3Z6030–135
R13	RESISTOR, fixed: comp; 400 ohms ±1%; ½ w.	Same as R1	3Z6040–99
R14	RESISTOR, fixed: comp; 500 ohms ±1%; ½ w.	Same as R1	3Z6050–244
R15	RESISTOR, fixed: comp; 600 ohms ±1%; ½ w.	Same as R1	3Z6060–101
R16	RESISTOR, fixed: comp; 700 ohms ±1%; ½ w.	Same as R1	3Z6070–33
R17	RESISTOR, fixed: comp; 800 ohms ±1%; ½ w.	Same as R1	3Z6080–69
R18	RESISTOR, fixed: comp; 900 ohms ±1%; ½ w.	Same as R1	3Z6090–37
R19	RESISTOR, fixed: comp; 1K ±1%; ½ w.	Same as R1	3Z6100–288
R20	RESISTOR, fixed: comp; 2K ±1%; ½ w.	Same as R1	3Z6200–206
R21	RESISTOR, fixed: comp; 3K ±1%; ½ w.	Same as R1	3Z6300–217
R22	RESISTOR, fixed: comp; 4K ±1%; ½ w.	Same as R1	3Z6400–125
R23	RESISTOR, fixed: comp; 5K ±1%; ½ w; Navy type No. 637330–1.	Same as R1	3Z6500–272
R24	RESISTOR, fixed: comp; 6K ±1%; ½ w.	Same as R1	3Z6560–82
R25	RESISTOR, fixed: comp; 7K ±1%; ½ w.	Same as R1	3Z6570–52
R26	RESISTOR, fixed: comp; 8K ±1%; ½ w.	Same as R1	3Z6580–43
R27	RESISTOR, fixed: comp; 9K ±1%; ½ w.	Same as R1	3Z6590–26
R28	RESISTOR, fixed: comp; 10K ±1%; ½ w.	Same as R1	3Z6610–326
R29	RESISTOR, fixed: comp; 20K ±1%; ½ w.	Same as R1	3Z6620–202
R30	RESISTOR, fixed: comp; 30K ±1%; ½ w.	Same as R1	3Z6630–118
R31	RESISTOR, fixed: comp; 40K ±1%; ½ w.	Same as R1	3Z6640–101
R32	RESISTOR, fixed: comp; 50K ±1%; ½ w.	Same as R1	3Z6650–215
R33	RESISTOR, fixed: comp; 60K ±1%; ½ w.	Same as R1	3Z6660–54
R34	RESISTOR, fixed: comp; 70K ±1%; ½ w.	Same as R1	3Z6670–28
R35	RESISTOR, fixed: comp; 80K ±1%; ½ w.	Same as R1	3Z6680–35
R36	RESISTOR, fixed: comp; 90K ±1%; ½ w.	Same as R1	3Z6690–16
R37	RESISTOR, fixed: comp; 2200 ohms ±5%; 1w; JAN type # RC30BF222J.	Drops r-f in tuned grid circuit of V1.	3RC30BF222J

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
R38	RESISTOR, fixed: comp; 6800 ohms ±5%; 1 w; JAN type # RC30BF682J.	Drops r-f in tuned plate circuit of V1.	3RC30BF682J
R39	RESISTOR, fixed: comp; 22K ±5%; 1 w; JAN type # RC30BF223J.	Grid leak resistor for V1..	3RC30BF223J
R40	RESISTOR, fixed: comp; 270 ohms ±10%; 1 w; JAN type # RC30BF271K.	Cathode bias resistor for V1.	3RC30BF271K
R46	RESISTOR, fixed: comp; 100 ohms ±10%; ½ w; JAN type # RC20BF101K.	Oscillation suppressor in plate circuit of V1.	3RC20BF101K
R47	RESISTOR, fixed: comp; 4700 ohms ±5%; ½ w; JAN type # RC20BF472J.	Drops r-f in plate circuit of V1.	3RC20BF472J
R43, R44, R45	RESISTOR, fixed: WW; 1600 ohms ±5%; 12 w; JAN type # RW32F162.	R43, R44—Filter output of V2. R45—Filters output of V2 and regulates d-c voltage to plate of V1.	3RW25521
R41	RESISTOR, variable: comp; 1K ±10%; 2 w; JAN type # RV4ANFK102A.	GRID CURRENT control resistor which adjusts the sensitivity of meter M1.	3RV31018
R42	RESISTOR, variable: comp; 25K ±10%; 2 w; JAN type # RV4ANFK253A.	CRYSTAL CURRENT control resistor; controls magnitude of oscillation by varying the voltage on the screen grid of V1.	3RV42524
X1, X2, X3, X4	SOCKET, tube: 8 cont octal; under chassis saddle mtg w/4 grid lugs; JAN type # TSB8T102.	Sockets for V1, V2, V3, and V4.	2Z8678.327
X5, X6	SOCKET, tube: 4 cont med; one piece saddle mtg.	X5—Socket for plug-in grid coil. X6—Socket for plug-in plate coil.	2Z8762.1
S7	SWITCH, lever: two position, nonlocking DPDT.	CALIBRATE — CRYSTAL control; switches either the test crystal or substitution decade resistors into oscillator circuit.	3Z9580-2.5
S1	SWITCH, rotary: 4 pole, 10 position; 4 sect.	Select a substitution resistor.	3Z9825-58.183
S2	SWITCH, rotary: 4 pole, 10 position; 4 sect.	Same as S1..............	3Z9825-58.184
S5	SWITCH, rotary: 2 pole, 7 position; 2 sect..	KILOCYCLES switch; changes frequency range by selecting various inductances.	3Z9825-39.2
S6	SWITCH, rotary: 1 pole, 2 position.......	S—A control; shorts out C2 (S position) for series-resonant test of crystal.	3Z9825-39.1

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
S3, S4	SWITCH, toggle: DPDT; 30 v d-c, 30 amp; JAN type # ST52N.	S3—X10-X1000 switch, changes resistance decades on switch S2. S4—X100-X10000 switch, changes resistance decades on switch S1.	3Z9863-52N



COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE			RMA VOLTAGE RATING
		RMA MICA-AND CERAMIC-DIELECTRIC	JAN MICA-AND PAPER-DIELECTRIC	JAN CERAMIC-DIELECTRIC	
BLACK	0	1	1	1	–
BROWN	1	10	10	10	100
RED	2	100	100	100	200
ORANGE	3	1,000	1,000	1,000	300
YELLOW	4	10,000	10,000		400
GREEN	5	100,000			500
BLUE	6	1,000,000			600
VIOLET	7	10,000,000			700
GRAY	8	100,000,000		0.01	800
WHITE	9	1,000,000,000		0.1	900
GOLD	–	0.1	0.1		1,000
SILVER	–	0.01	0.01		2,000
NO COLOR	–				500

NOTES

* THE SILVER DOT IDENTIFIES THIS MARKING FOR WORKING VOLTAGES SEE JAN TYPE DESIGNATION CODE.

≠ THE BLACK DOT IDENTIFIES THIS MARKING FOR WORKING VOLTAGES - SEE JAN TYPE DESIGNATION CODE

** CAPACITORS MARKED WITH THIS CODE HAVE A VOLTAGE RATING OF 500 VDCW EITHER THE BAND OR DOT CODE MAY BE USED FOR BOTH INSULATED (AXIAL-LEAD) OR UNINSULATED (RADIAL-LEAD) CAPACITORS

RMA RADIO MANUFACTURERS ASSOCIATION

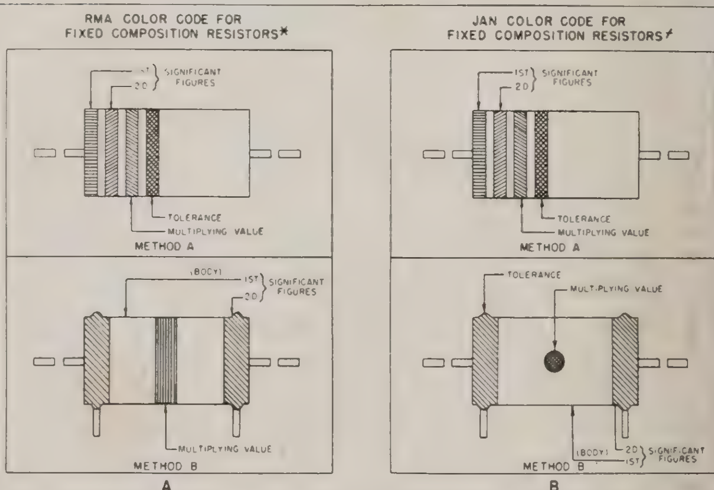
JAN JOINT ARMY-NAVY

THESE COLOR CODES GIVE CAPACITANCES IN MICROMICROFARADS

TL 324535

Figure 16. Capacitor color codes.

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
S8	SWITCH, toggle: SPST; 30 d-c v, 20 amp; JAN type # ST42A.	Power switch; controls a-c into the CI meter.	3Z9863-42A
T1	TRANSFORMER, power: fil and plate type; input 115 v, 50–1720 cyc, single-phase; secd #1, 700 v ct at 35 ma, #2, 5.0 v at 3 amp, #3, 6.3 v at 2.5 amp; HS metal case.	Power supply transformer	2Z9613.645
V1	TUBE, electron: JAN type # 6V6GTY....	Oscillator tube...........	2J6V6GTY
V2	TUBE, electron: JAN type # 5Y3GT.....	Rectifier tube............	2J5Y3GT
V3, V4	TUBE, electron: RMA type No. 0C3W....	Regulate d-c voltage to plate and screen of V1.	2J0C3W



COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE	TOLERANCE (%)
BLACK	0	1	± –
BROWN	1	10	± 1
RED	2	100	± 2
ORANGE	3	1,000	± 3
YELLOW	4	10,000	± 4
GREEN	5	100,000	± 5
BLUE	6	1,000,000	± 6
VIOLET	7	10,000,000	± 7
GRAY	8	100,000,000	± 8
WHITE	9	1,000,000,000	± 9
GOLD	–	0.1	± 5
SILVER	–	0.01	± 10
NO COLOR	–	–	± 20

NOTES

* INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A NATURAL TAN BACKGROUND COLOR NON-INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A BLACK BACKGROUND

† RESISTORS WITH AXIAL LEADS ARE INSULATED RESISTORS WITH RADIAL LEADS ARE NON-INSULATED

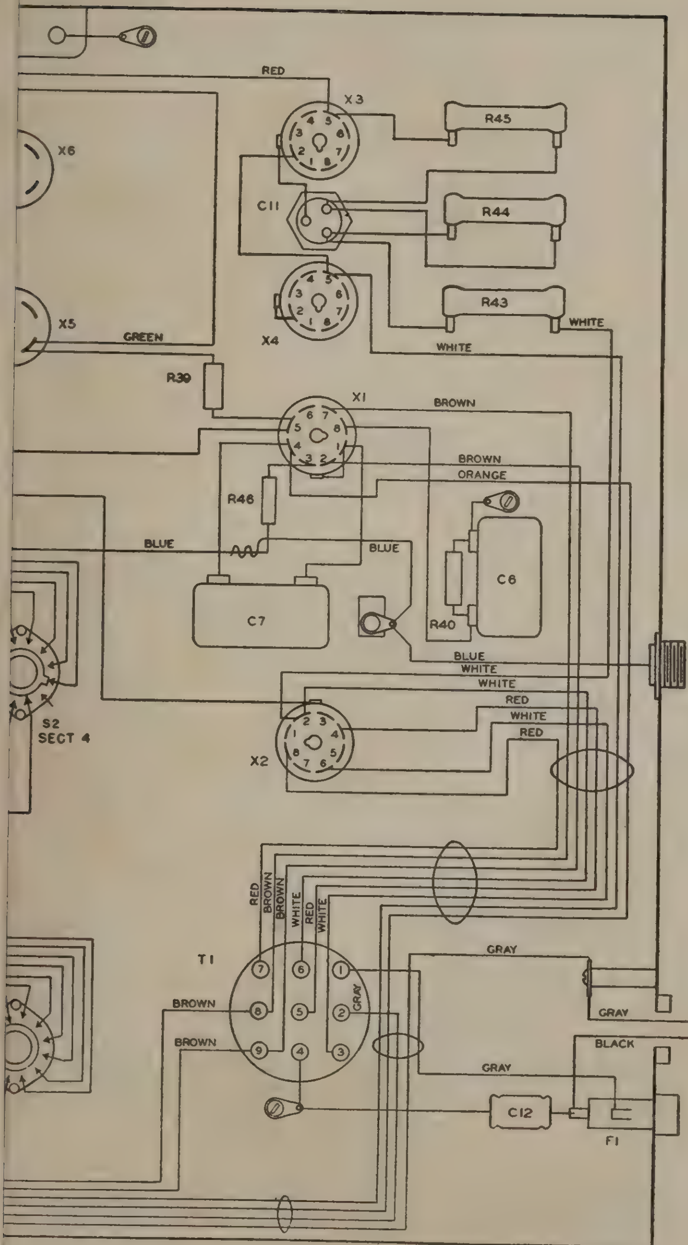
RMA RADIO MANUFACTURERS ASSOCIATION

JAN JOINT ARMY-NAVY

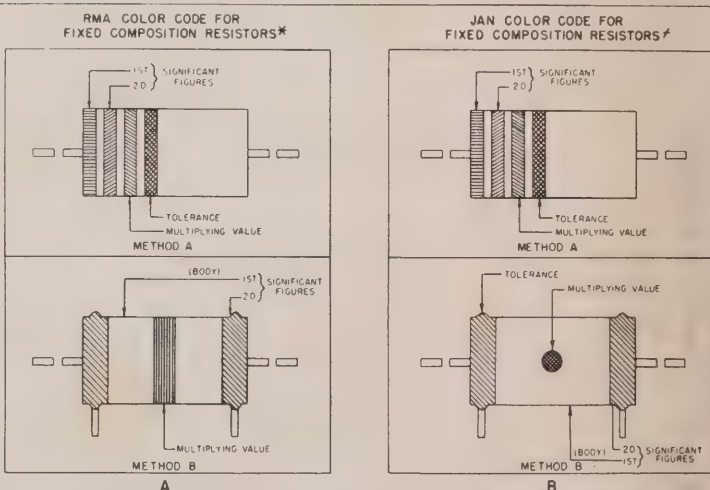
THESE COLOR CODES GIVE ALL RESISTANCE VALUES IN OHMS

TL 32454S

Figure 17. Resistor color codes.


RED
X3
R45
X6
C11
R44
R43
X5
GREEN
WHITE
X4
WHITE
R39
X1
BROWN
BROWN
ORANGE
R46
BLUE
BLUE
C6
C7
R40
BLUE
WHITE
WHITE
RED
S2
SECT 4
WHITE
RED
X2
RED
BROWN
BROWN
WHITE
RED
WHITE
T1
GRAY
BROWN
GRAY
GRAY
BROWN
BLACK
GRAY
C12
F1
TM 5052-10

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
S8	SWITCH, toggle: SPST; 30 d-c v, 20 amp; JAN type # ST42A.	Power switch; controls a-c into the CI meter.	3Z9863-42A
T1	TRANSFORMER, power: fil and plate type; input 115 v, 50–1720 cyc, single-phase; secd #1, 700 v ct at 35 ma, #2, 5.0 v at 3 amp, #3, 6.3 v at 2.5 amp; HS metal case.	Power supply transformer.	2Z9613.645
V1	TUBE, electron: JAN type # 6V6GTY....	Oscillator tube..........	2J6V6GTY
V2	TUBE, electron: JAN type # 5Y3GT.....	Rectifier tube...........	2J5Y3GT
V3, V4	TUBE, electron: RMA type No. 0C3W....	Regulate d-c voltage to plate and screen of V1.	2J0C3W



COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE	TOLERANCE (%)
BLACK	0	1	± -
BROWN	1	10	± 1
RED	2	100	± 2
ORANGE	3	1,000	± 3
YELLOW	4	10,000	± 4
GREEN	5	100,000	± 5
BLUE	6	1,000,000	± 6
VIOLET	7	10,000,000	± 7
GRAY	8	100,000,000	± 8
WHITE	9	1,000,000,000	± 9
GOLD	—	0.1	± 5
SILVER	-	0.01	± 10
NO COLOR	-	—	± 20

NOTES

* INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A NATURAL TAN BACKGROUND COLOR. NON-INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A BLACK BACKGROUND

† RESISTORS WITH AXIAL LEADS ARE INSULATED. RESISTORS WITH RADIAL LEADS ARE NON-INSULATED

RMA RADIO MANUFACTURERS ASSOCIATION

JAN JOINT ARMY-NAVY

THESE COLOR CODES GIVE ALL RESISTANCE VALUES IN OHMS

TL 32454S

Figure 17. Resistor color codes.

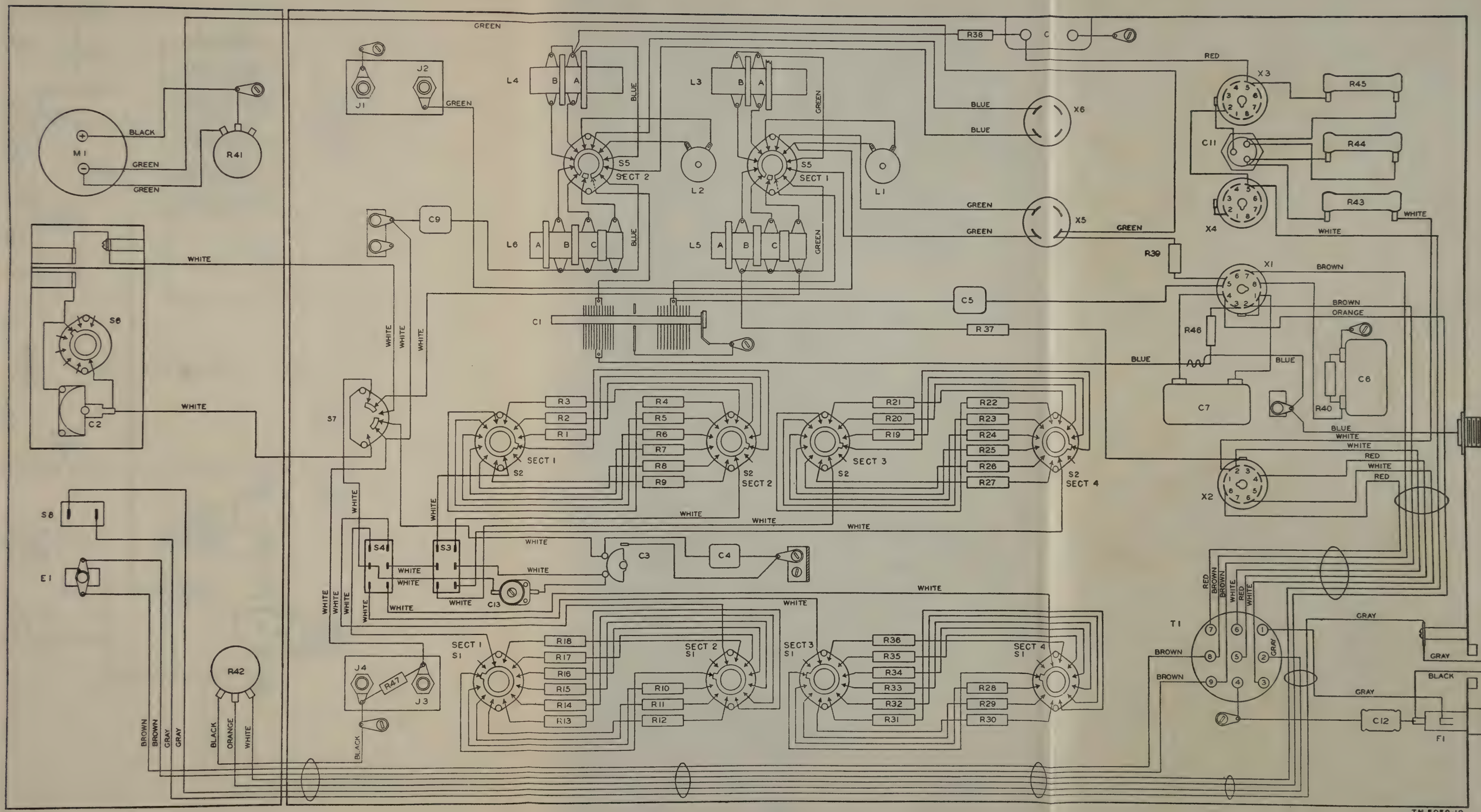
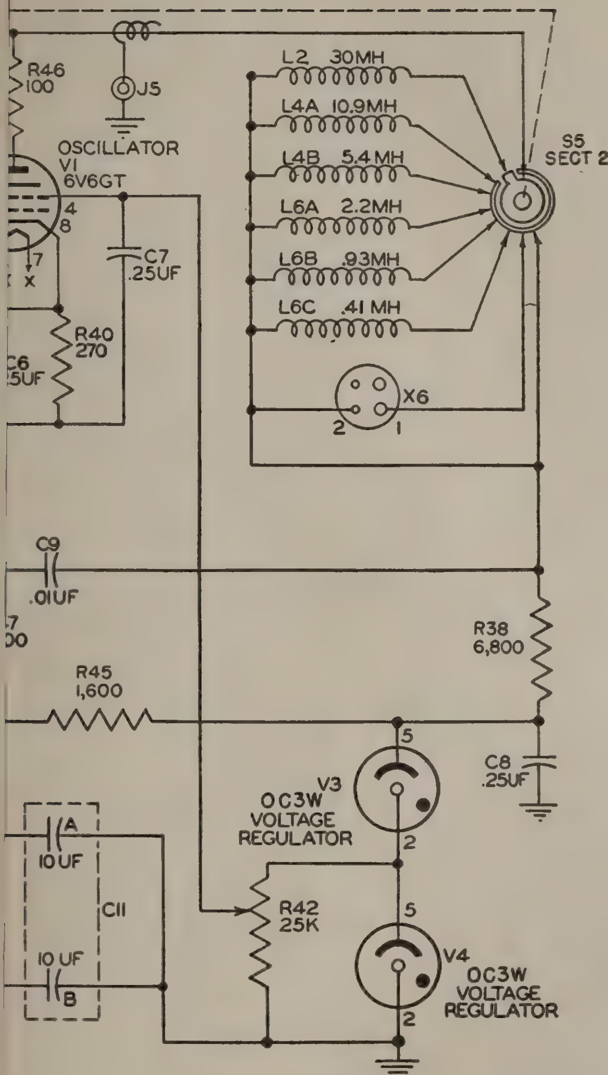
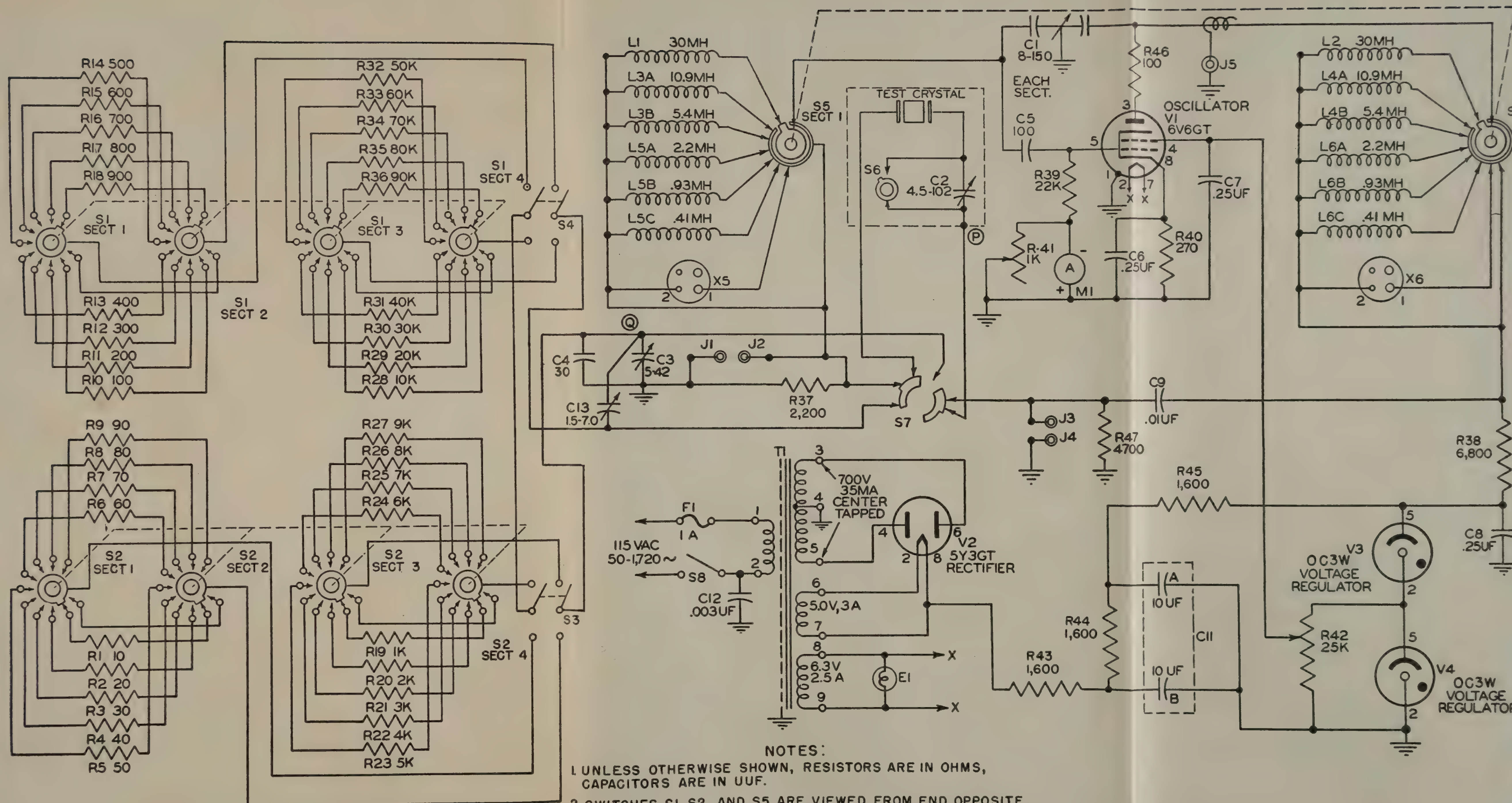


Figure 18. Wiring diagram.



R46
100
J5
OSCILLATOR
V1
6V6GT
4
8
7
X
C7
.25UF
R40
270
C6
.25UF
L2 30MH
L4A 10.9MH
L4B 5.4 MH
L6A 2.2MH
L6B .93MH
L6C .41 MH
S5
SECT 2
X6
2
1
C9
.01UF
R38
6,800
R45
1,600
5
V3
OC3W
VOLTAGE
REGULATOR
2
C8
.25UF
A
10 UF
C11
10 UF
B
R42
25K
5
V4
OC3W
VOLTAGE
REGULATOR
2

TM 5052-12



NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. SWITCHES S1, S2, AND S5 ARE VIEWED FROM END OPPOSITE CONTROL KNOB. SECTIONS DESIGNATED "1" ARE NEAREST THE KNOB END.
3. R1 TO R36 INCL ARE $\frac{1}{2}$ WATT, 1% TOLERANCE RESISTORS.

TM 5052-12

Figure 19. Complete over-all schematic diagram.

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